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JACA Corp., Fort Washington, PA

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A national workshop on the disposal of pesticide wastes was held in Denver, Colorado on January 28-29, 1985. The purpose of this workshop was to work with government, pesticide user groups, pesticide producers, farm organizations, and academia to define practical solutions to pesticide users' disposal problems.

This publication is a compilation of the speakers' papers and a transcript of the summary panel. It covers the following topics: Applicator Disposal Needs; Disposal Technology Options including physical treatment options, biological options, chemical treatment options, land application option, and incineration options; storage, handling, and shipments of pesticide wastes; and Empty Pesticide Container Disposal Programs.

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PROCEEDINGS: NATIONAL WORKSHOP ON PESTICIDE WASTE DISPOSAL

Denver, Colorado, January 28-29, 1985

by

JACA Corporation
Fort Washington, Pennsylvania 19034

Contract No. 68-03-3131

Project Officer

James Bridges
Office of Program Operations
Hazardous Waste Engineering Research Laboratory
Cincinnati, Ohio 45268

HAZARDOUS WASTE ENGINEERING RESEARCH LABORATORY
WATER ENGINEERING RESEARCH LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
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DISCLAIMER

The following papers have been reviewed in accordance with the U.S. Environmental Protection Agency's peer and administrative review policies and approved for presentation and publication:

Federal Regulation of Pesticide Disposal
Land Disposal of Pesticide Rinsate
Incineration Options for Disposed of Waste Pesticides
Storage, Handling and Shipment of Pesticide Waste - Regulatory Requirements

The following papers describe work that has not been funded by the U.S. Environmental Protection Agency and therefore the contents do not necessarily reflect the views of the Agency and no official endorsement should be inferred.

Overview: Pesticide Wastes Disposal
Applicator Disposal Needs
Pesticide Wastes Disposal: An Agricultural Aviator's Perspective
Pesticide Wastes Disposal: A Private Applicator's Perspective
California Regulatory Requirements
Pesticide Degradation Properties
Physical Treatment Options: Removal of Chemicals from Wastewater by Adsorption, Filtration and/or Coagulation
A Practical System to Treat Pesticide-Laden Wastewater
Pesticide Wastewater Disposal: Biological Methods
Chemical Treatment Options for Pesticide Wastes Disposal
The Logistics of Transporting Pesticide Wastes From the User to Disposer
Empty Pesticide Container Management: An Overview
Alberta Pesticide Container Collection Program
Maine's Returnable Pesticides Container Program

FOREWORD

The U.S. Environmental Protection Agency is charged by Congress with protecting the Nation's land, air, and water systems. Under a mandate of national enviornmental laws, the agency strives to formulate and implement actions leading to a compatible balance between human activities and the ability of natural systems to support and nurture life. The Clean Water Act, the Safe Drinking Water Act, and the Toxic Substances Control Act are three of the major congressional laws that provide the framework for restoring and maintaining the integrity of our Nation's water, for preserving and enhancing the water we drink, and for protecting the environment from toxic substances. These laws direct the EPA to perform research to define our environmental problems, measure the impacts, and search for solutions.

The Water Engineering Research Laboratory is that component of EPA's Research and Development program concerned with preventing, treating, and managing municipal and industrial wastewater discharges; establishing practices to control and remove contaminants from drinking water and to prevent its deterioration during storage and distribution; and assessing the nature and controllability of releases of toxic substances to the air, water, and land from manufacturing processes and subsequent product uses. This publication is one of the products of that research and provides a vital communication link between the researcher and the user community.

The national workshop on the disposal of pesticide wastes was developed to provide a national forum that assembled pesticide users, pesticide producers, federal and state agencies and agricultural and environmental researchers to collectively address the complex issues of pesticide waste disposal and serve as a basis for continued dialogue and interaction. The Office of Research and Development with the Office Pesticide Programs sponsored the development of these Proceedings to document the conduct of this solution-oriented workshop. It is hoped that the content of these Proceedings will stimulate action to reduce pollution by illustrating approaches and techniques highlighted by the wealth of excellent papers presented at the workshop.

Francis T. Mayo, Director
Water Engineering Research Laboratory

ABSTRACT

A national workshop on the disposal of pesticide wastes was held in Denver, Colorado, on January 28-29, 1985. The purpose of this workshop was to work with government, pesticide user groups, pesticide producers, farm organizations, and academia to define practical solutions to pesticide users' disposal problems.

This publication is a compilation of the speakers' papers and a transcript of the summary panel. The following topics are covered: disposal needs; Federal/State regulatory requirements; pesticide degradation properties; disposal technology options, including physical treatment options, biological options, chemical treatment options, land application option, and incineration option; storage, handling, and shipments of pesticide wastes; and empty pesticide container disposal programs.

This report was submitted in fulfillment of Contract No. 68-03-3131 by the JACA Corporation under the sponsorship of the U.S. Enviromental Protection Agency. This report covers the period October 1984 to July 1985, and work was completed as of June 30, 1985.

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The workshop was sponsored by the following organizations:

American Chemical Society (Division of Pesticide Chemistry)
American Farm Bureau Federation
American Society of Agricultural Engineers
Association of American Pesticide Control Officials, Inc.
National Agricultural Aviation Association
National Agricultural Chemicals Association
National Alliance of Independent Crop Consultants
National Forest Products Association
U.S. Department of Agriculture (Science and Education and Soil Conservation Service)
U.S. Environmental Protection Agency (Hazardous Waste Engineering Research Laboratory and Water Engineering Research Laboratory) Office of Pesticide Programs

A special note of appreciation is extended to Mr. Roy R. Detweiler, Chairperson of the Workshop Coordinating Committee and Mr. Thomas J. Gilding, Workshop Coordinator. Also many thanks are given to Ms. Elaine McDonald and Ms. Marilyn McKinnis for all their contributions in making sure the workshop ran smoothly. These individuals along with the members of the Workshop Coordinating Committee worked diligently to make this National Workshop on Pesticide Waste Disposal an overwhelming success.

PROGRAM

Chairman: Roy R. Detweiler
E. I. duPont deNemours & Co.

January 28, 1985

8:30 - 8:40 a.m.	Opening Remarks
8:40 - 9:00 a.m.	Overview
9:00 - 10:00 a.m.	Applicator Disposal Needs; Panel
10:00 - 10:40 a.m.	Federal/State Regulatory Requirements
11:00 - 11:30 a.m.	Pesticide Degradation Properties

Disposal Technology Options

11:30 - 12:15 p.m.	Physical Treatment Options
2:00 - 2:45 p.m.	Biological Options
2:45 - 3:30 p.m.	Chemical Treatment Options
3:30 - 4:15 p.m.	Land Application Option
4:15 - 5:00 p.m.	Incineration Option

January 29, 1985

8:30 - 9:15 a.m.	Storage, Handling and Shipments of Pesticide Wastes
9:15 - 10:15 a.m.	Empty Pesticide Container Disposal
10:45 - 12:15 p.m.	Workshop Summary Panel
12:15 - 12:30 p.m.	Adjournment

OVERVIEW: PESTICIDE WASTES DISPOSAL

Orlo R. Ehart
Wisconsin Department of Agriculture, Trade
and Consumer Protection
Madison, WI 53708

ABSTRACT

A major agreement must be reached on what can be done, legally and technically, to deal with the difficulties of proper pesticide related waste disposal, and who should share in the cost of a clean environment. Many potential problems exist; however, the wastes from mixing, loading and cleaning operations present the greatest challenge for pesticide applicators. Although the current laws and regulations must form the state-of-the-art for required disposal techniques, more appropriate incentives, less burdensome governmental mandates which appropriately protect the environment, and more feasible, technological solutions are needed in the future. Although past disposal problems and future policy changes are of major importance, the primary focus must be the solutions to the existing problems facing the pesticide user industry today.

INTRODUCTION

In 1976, the U.S. Congress passed the Resource Conservation and Recovery Act (RCRA) which amended the Solid Waste Disposal Act (SWDA). This legislation regulates disposal of wastes, including pesticides which may create a hazard, to assure minimum effects on human health and the environment. The law places the burden of protecting the environment on all users and handlers of hazardous materials, which may include both active and/or inert ingredients of some pesticides.

Pesticides are intended to control or kill harmful plants, insects, germs, bacteria, plant diseases, etc., but for lack of specificity may be hazardous to the environment. Pesticide commerce and use are regulated under the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) and by state law and rules. However, once applications of pesticides are completed, any excess pesticide concentrate, unapplied diluted pesticide, and discarded pesticide containers may be regulated as wastes, some of which may be considered hazardous.

REGULATIONS

Containers, if triple rinsed or its equivalent, are not regulated as hazardous waste but still must be disposed of properly, generally in accordance with label directions and in some situations under additional state rules. Disposal of containers that are not triple rinsed is regulated according to the ingredients they contained; some pesticides are regulated as toxic waste, others as acutely toxic waste ("acute hazardous"), and still others are regulated by their properties or characteristics; some are not regulated. Most of the pesticide products sold in the United States are not regulated as hazardous waste.

The rules concerning regulated wastes (Code of Federal Regulations (CFR), (1980), Title 40, Parts 261-276; and companion state rules) apply to those who generate, store, treat, transport or dispose of these wastes. The list of regulated wastes is quite voluminous; materials are listed by their chemical names. Several pesticide active ingredients are included as regulated wastes (Tables 1 and 2).

TABLE 1

"ACUTE HAZARDOUS" COMMERCIAL PESTICIDE PRODUCTS[1, 2, 3]

Active Ingredient	Common or Trade Name
Acrolein	Aqualin, Acrylaldehyde, Magnacide H
Aldicarb	Temik
Aldrin	
Allyl alcohol	
Alpha-Naphthylthiourea	ANTU
Aluminum phosphide	Phostoxin, Delicia
4-Aminopyridine	Avitrol
Arsenic acid	orthoarsenic acid
Arsenic pentoxide	
Arsenic trioxide	
Calcium cyanide	Cyanogas
Carbon disulfide	
p-Chloroaniline	
Cyanides	soluble cyanide salts
Cyanogen chloride	
2-Cyclohexyl-4, 6-dinitrophenol	Dinex
Dieldrin	
O,O-Diethyl S-[2-ethylthio)-ethyl] phosphorodithioate	disulfoton;Di-Syston, Dithiodemeton, Dithiosystox, Thiodemeton
O,O-Diethyl O-pyrazinyl phosphorothioate	thionazin, cynen; Zinophos, Nemafos
Dimethoate	Cygon, De-Fend, Rogor
O,O-Dimethyl O-p-nitrophenyl phosphorothioate	methyl parathion, thiophosphate
4,6-Dinitro-O-cresol and salts	Dinitro, Sinox
4,6-Dinitro-O-cyclohexylphenol	dicyclohexylamine salt
2,4 Dinitrophenol[4]	
Dinoseb	Dinitro, DNBP
Disulfoton	Di-Syston
Endosulfan	Thiodan
Endothall	Aquathol
Endrin	
Famphur	Warbex
Fluoroacetamide	Compound 1081
Heptachlor	
Hexaethyl tetraphosphate	HEPT
Hydrocyanic acid	
Hydrogen cyanide	
Magnesium phosphide	Magtoxin
Methomyl	Lannate, Nudrin
Methyl parathion	
Nicotine and salts	Black Leaf 40
Octamethylpyrophosphoramide	schradan, OMPA
Parathion	ethyl parathion
Phenylmercuric acetate	PMA
Phorate	Thimet
Potassium cyanide	
Propargyl alcohol	
Schradan	OMPA
Sodium azide	Kazoe, Smite
Sodium cyanide	Cymag
Sodium fluoroacetate	Compound 1080
Strychnine and salts	
O,O,O,O-Tetraethyl dithiopyrophosphate	Sulfotepp, Bladafume
Tetraethyl pyrophosphate	TEPP
Thallium sulfate	
Thiofanox	Dacamox
Toxaphene	octochlorocamphene; Camphechlor, Alltex, Toxakil
Warfarin[5]	Coumafene, Coumaphene, Dethmor
Zinc phosphide[6]	ZP

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[1] Pesticide active ingredients also found in Table E of 40 CFR, Part 261, Subpart D.

[2] Some information on pesticide active ingredients provided by Office of Pesticide Program staff, USEPA, Washington, DC.

[3] The author neither implies nor intends endorsement or criticism of products nor assumes any responsibility for inadvertently omitting any products.

[4] 1,4-Dinitrophenol is listed as a pesticide active ingredient.

[5] When the commercial chemical product is greater than 0.3% warfarin.

[6] When the commercial chemical product is greater than 10% zinc phosphide.

TABLE 2

"TOXIC" COMMERCIAL PESTICIDE PRODUCTS[1, 2, 3]

Active Ingredient	Common or Trade Name
Acetone	
Acetonitrile	Acrylofume
Acrylonitrile	cyanoethylene; Acritet
Amitrole	Cytrol, Weedazol
Benzene	
Bis(2-ethylhexyl) phthalate	
Cacodylic acid	Phytar, Rad-E-Cate, Arsan, Silvisar
Carbon tetrachloride	
Chloral hydrate	
Chlorobenzilate	Acaraben
Chlordane, technical	synklor; Chlor Kill, Orthoklor
Chlordecone	Kepone
Chlorobenzene	
4-Chloro-m-cresol	
Chloroform	
O-Chlorophenol	
4-Chloro-O-toluidine hydrochloride[4]	
Creosote	
Cresylic acid	Cresols
Cyclohexane	
Cyclohexanone	
Cyclophosphamide	Endoxan
Decachlorooctahydro-1,3, 4-metheno-2H-cyclobuta-[c,d]-pentalen-2 - one	chlordecone; Kepone
Diallate	Avadex, DATC
1,2-Dibromo-3-chloropropane	DBCP, Nemagon, Fumazone
Dibutyl phthalate	
S-2,3-(Dichloroallyl) diisopropylthiocarbamate	diallate; Avadex, DATC
O-Dichlorobenzene	orthodichlorobenzene
p-Dichlorobenzene	paradichlorobenzene; Moth Crystals

"TOXIC" COMMERCIAL PESTICIDE PRODUCTS Continued

Active Ingredient	Common or Trade Name
Dichlorodifluoromethane	Freon 12, Propellant 12
3,5-Dichloro-N-(1, 1-dimethyl-2-propynyl) benzamide	pronamide; Kerb, Propyzamide
Dichloro diphenyl dichloroethane	DDD, TDE
Dichloro diphenyl trichloroethane	DDT
Dichloroethyl ether	Chlorex
2,4-Dichlorophenoxyacetic acid, salts and esters	2,4-D
1,2-Dichloropropane	Propylene dichloride
1,3-Dichloropropene	Telone, D-D Mixture, Nemex, Vidden D
Dimethyl phthalate	DMP
Ethyl acetate	
Ethyl 4,4'-dichlorobenzilate	chlorobenzilate, Acaraben
Ethylene dibromide	EDB, Bromofume, Dowfumen-85, Pestmaster EDB-85, Soilbrom-85
Ethylene dichloride	EDC
Ethylene oxide	Oxirane
Formaldehyde	
Furfural	
Hexachlorobenzene	HCB, Anticarie, No Bunt
Hexachlorocyclohexane; gamma isomer	benzene hexachloride, gamma isomer; lindane
Hexachlorocyclopentadiene	
Hexachloroethane	Avlothane
Hexachlorophene	
Hydrofluoric acid	
Isobutyl alcohol	
Lead acetate	
Lindane	

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[1] Pesticide active ingredients also found in Table F of 40 CFR, Part 261, Subpart D.

[2] Some information on pesticide active ingredients provided by Office of Pesticide Program staff, USEPA, Washington, D.C.

[3] The author neither implies nor intends endorsement or criticism of products nor assumes any responsibility for inadvertently omitting any products.

[4] 3-Chloro-p-toluidine hydrochloride (Starlicide) listed as active ingredient.

"TOXIC" COMMERCIAL PESTICIDE PRODUCTS
Continued

Active Ingredient	Common or Trade Name
Maleic hydrazide	MH_{30}, Slo-Gro, Sucker-Stuff, Retard
Mercury	
Methyl alcohol	Methanol
Methyl bromide	
Methyl chloride	
2,2'-Methylenebis (3,4,6-trichlorophenol)	hexachlorophene; G-11
Methylene chloride	MEK
Methyl ethyl ketone	
4-Methyl-2-pentanone	methyl isobutyl ketone; MIBK
Naphthalene	Moth Balls
Nitrobenzene	
p-Nitrophenol	
Pentachloroethane	
Pentachloronitrobenzene	PCNB, Quintozene, Tritisan, Terraclor
Pentachlorophenol	Penta, PCP
Perchlorethylene	tetrachloroethylene
Phenol	carbolic acid
Phosphorodithioic acid, O,O-diethyl, methyl ester	
Pronamide	Kerb
Propylene dichloride	
Pyridine	
Resorcinol	
Safrole	

"TOXIC" COMMERCIAL PESTICIDE PRODUCTS
Continued

Active Ingredient	Common or Trade Name
Selenium disulfide	
Silvex	
1,2,4,5-Tetrachlorobenzene[5]	
1,1,2,2-Tetrachloroethane	
Tetrachloroethylene	perchlorethylene
2-(2,4,5-Trichlorophenoxy) propionic acid	silvex
2,3,4,6-Tetrachlorophenol	
Thiram	Arasan, Thylate, TMTD, Spotrete, Delsan, Pomarsol, Tersan
Toluene	
1,1,1-Trichloroethane	methyl chloroform; Methoxychlor, Marlate
Trichloroethylene	
Trichloromonofluoromethane	Freon 11, Propellant 11
2,4,5-Trichlorophenol	Dowicide 2
2,4,6-Trichlorophenol	Dowicide 2S
2,4,5-Trichlorophenoxyacetic acid	2,4,5-T
Xylene	
Warfarin[6]	Coumafene, Coumaphene, Dethmor
Zinc phosphide[7]	ZP

---

[5] 1,2,3,4 Tetrachlorobenzene is listed as a pesticide active ingredient.
[6] When the commercial chemical product is 0.3% or less warfarin.
[7] When the commercial chemical product is 10% or less zinc phosphide.

The pesticides in this publication are listed alphabetically according to the active ingredient named in the statement on the front panel of the pesticide container; some are listed under both common name and scientific chemical name. Common names and/or trade names follow the active ingredient name where they exist to identify any pesticide also designated as an "acute hazardous" (Table 1) or "toxic" (Table 2) material. The list includes some chemicals once sold as pesticides but no longer marketed as pesticide active ingredients. The chemicals found in the CFR as regulated wastes frequently are named by a different nomenclature than that used in naming pesticide active ingredients. The names found in this publication are those found in the Third Edition of Acceptable Common Names and Chemical Names for the Ingredient Statement on Pesticide Labels (1975) and may not necessarily be found under the listed name in 40 CFR, Part 261.

The lists included in this publication do not contain commercial chemical products that may become regulated wastes as a result of the EPA's Hazardous Waste Management System; Dioxin-Containing Wastes rule (1985). In addition by early 1986, according to the Hazardous and Solid Waste Amendments of 1984, EPA must determine whether or not to list as "acute hazardous" or "toxic" wastes products containing any of the following: chlorinated aliphatics, dioxin, carbamates, bromacil, linuron, organo-bromines, solvents and chlorinated aromatics. The impact of this review may significantly impact a large number of pesticide products currently not listed.

Even if a pesticide is not listed in Tables 1 and 2, it may still be a regulated waste. If the pesticide is ignitable (flash point below 140° F.), corrosive (pH less than 2 or greater than 12.5), reactive (potential for chemical reactions), or "extraction procedure toxic" (contains an active ingredient above a maximum concentration determined by a specified extraction test), the pesticide is regulated as a "hazardous waste" (40 CFR, Part 261, Subpart C and companion state rules).

If 2.2 pounds (1 kilogram) or more of any "acute hazardous" pesticide waste (Table 1) is accumulated in any month, SWDA and the corresponding state laws and rules require the generator to dispose of this waste in a hazardous waste facility. When the limit of 2.2 pounds of waste is exceeded, approximately 1 quart of material including diluent of "acute hazardous" products, the law requires the generator to obtain a number from the Environmental Protection Agency (EPA) or the State Lead Agency (SLA) administering SWDA to dispose of the waste in an approved, regulated hazardous waste landfill site. The entire waste, no matter how dilute, must be treated as if it were "acute hazardous" material. Therefore, it is prudent to segregate all "acute hazardous" material from other wastes during storage to reduce the cost and effort of disposal.

Several commercial and private pesticide applicators and pesticide dealers may have to become official "waste generators" to dispose of leftover pesticides. Some regulated landfills require an identification number from anyone attempting to dispose of any pesticide wastes, regardless of whether or not the pesticide is a "toxic" or "acute hazardous" material. Landfill operators have the right to be more restrictive than the law; in turn, this places more burdens on the waste generator, the pesticide applicator or dealer. When landfill operators are more restrictive, however, a dilemma is created for applicators as all wastes are then handled as if they were "acute hazardous" wastes. Since SWDA allows persons to be held strictly liable for past disposal practices, such reactions by landfill operators are to be expected.

Table 2 lists pesticide active ingredients classified as "toxic" wastes. If 2,200 pounds (1,000 kilograms or approximately 284 gallons) or more of waste of these products is generated in any month, a generator number is required for disposal of the waste.

A number must be obtained from EPA or the SLA administering SWDA if the 2,200 pounds of "toxic" waste or 2.2 pounds of "acute hazardous" waste are reached in any one month, without regard to the amount of waste which may be generated in other months. It also bears repeating that the waste includes the diluent as well as the pesticide. Therefore, during the application season the water used to clean a spray rig for applications made during a month, in and of itself, may be enough to require an applicator to obtain a waste generator number. Additionally, it would appear that any liquid spray mixture of any formulation of pesticide active ingredients found in Table 1 would result in sufficient waste water and/or leftover spray mixture to require many commercial applicators to become recognized waste generators.

The 1984 amendments to SWDA require the EPA to promulgate standards for waste in quantities greater than 100 and less than 1000 kg/mo. These standards may vary from the existing regulations, but must protect human health and the environment. Therefore, the information detailed in this paper may be modified by rules expected by March 31, 1986 (Schaffer, 1985).

CONFERENCE FOCUS

The pesticide use versus disposal issue can be equated to a heavyweight title fight. In the one corner, representing the pesticide disposal interests, are the NIMBYs, the Not In My Back Yard philosophy people. Representing the NIMBYs is Hester Foster. Hester Foster has been known to have problems turning on her radio ever since she learned that herbicides could be broadcast. (Guindon, 1984)

In the other corner, representing the pesticide users, is the pesticide applicators' industry. They have not yet selected their actual participant for the bout. Suffice it to say, they, too, have a choice between the extremely professional representative and an unaware, ill informed user. It is obvious that currently differing philosophies along a long spectrum of concerns exists; some rightful, some not.

Differing philosophies in the way that disposal and use are regulated also exist. On the one hand is the SWDA and on another hand is the FIFRA. These laws are very similar in the way that they mandate handling some of the disposal issues; in some other ways they establish inconsistent requirements. Communication may in some instances be inhibited between the administrators of the SWDA and FIFRA on a state level since frequently the programs are administered through different SLAs. The conference participants will focus upon the existing policies, the plight of the pesticide users and what can be done to minimize their problems and better define their concerns.

This discussion cannot ensue, however, without the recognition that there is going to be an increased cost associated with the solutions to the pesticide waste disposal dilemma. For example, in an Iowa study in 1974, Ryan (1974) asked farmers how much they would be willing to pay, as an increased cost per year, to dispose of pesticide containers. The answer was $10.00. The same question was asked of commercial pesticide applicators and dealers; their answers were $20.00 to $30.00. That questionnaire hasn't been repeated, however, considerable increases in prices people are willing to pay today to rid themselves of pesticide waste disposal burdens might be anticipated.

It also must be recognized, that the Hester Fosters of the world are not all wrong, even though they may be sometimes uninformed. It must be accepted that problems do exist, and they need to be addressed. That is, of course, the reason for the conference.

PROBLEMS, ISSUES AND POLICIES

The sources of potential problems are as follows: The containers; unwanted, unuseable and unidentifiable products; tank rinse waters; leftover materials; equipment wash waters; incompatible mixtures; spilled materials from accidents; stormwater and run-off from natural occurrences; and debris from fires.

In order to understand how these sources may be potential problems, it is necessary to recognize how wastes are designated. In addition to the two methods previously indicated, by listing or testing, a product may be designated as a hazardous waste simply by the owner declaring it as hazardous waste. This occurs most generally when a waste is suspected to be a hazardous waste and the owner decides not to incur the potential additional expense of determining the actual contents of the materials. This may also occur at the insistence of hazardous waste disposal facility operators who wish to reduce their liabilities.

Who determines when a pesticide is a waste? That question has been asked many times in recent months and the answer is always, "It is the person who is the owner of the pesticide." However, there is also another caveat to the answer which is not articulated. The caveat is that a regulator may decide that the activity is unacceptable, and therefore, determine that the pesticide is a waste for the owner.

Is recycling the answer to the pesticide disposal problem? It is only partially the answer. The philosophy of recycling is more appropriate to solvents which may have continued uses than it is to pesticide wastes. People who stress recycling as the alternative to disposal are generally unaware of the pesticide users' inability to find a buyer for a few gallons of diluted pesticide product of which the effacacy is in question. In addition, recycling does not merely mean finding another use for a pesticide drum. In experiments conducted in Wisconsin after triple rinsing and then re-rinsing with acetone, pesticide active ingredient was still found in every container (Myrdal, 1984).

If a pesticide is used at one rate, can it be disposed of on land at that same rate? It depends upon several factors, but, in general, SWDA policy condemns that approach. The State Issues, Research and Evalutation Group (SFIREG) Committee on Groundwater Protection and Pesticide Waste Disposal has identified that problem as one of the major issues needing resolution.

There are several options and policies currently in place which must be reviewed in order to better understand the issues related to the disposal of pesticide waste.

The containers: Recycling and disposal are the two options of getting rid of them which are quite frequently suggested. As mentioned before, if the containers have been triple rinsed they may be recycled, in some circumstances, directly back to manufacturers; they can also go to scrap metal dealers. The triple rinse requirement is like the seat belt law. The statistics associated with the advantages of using seat belts are well known, but many do not take the time to actually follow through with their use. The same is true of triple rinsing. Until the provisions are strictly enforced, compliance will be minimal.

If the containers are to be disposed, they must be placed in a landfill, sometimes in an approved landfill, depending on state regulations, and, if the farm exemption is allowed, they may be disposed on the farm. If the containers are not triple rinsed the containers remain regulated according to their contents.

Label directions on the pesticide container may require other specific actions. Therefore the label must be consulted before any actions can be taken, regardless of whether the SWDA requirements are understood. Many labels, however, have poorly written language which is difficult to interpret. Some changes in label language have been required by PR Notice 83-3 (Campt, 1983). That language does standardize the language required, however, it still does not simplify the label language to the extent necessary. For example, the suggested wording required by the label improvement program (LIP) may have eliminated the SWDA farmer exemption. There apparently is a notice coming out of EPA that may allow the continuation of the farmer exemption. If a notice is needed to explain the policy it appears the suggested LIP language is unclear and needs to be reviewed.

The unwanted, unuseable and unidentifiable products: Since no incentives exist for clean up and most users do not recognize the potential for a spill problem in their storage area, this issue is neglected until the sites are a problem and/or they are abandoned. It is apparently considered to be a better philosophy to create a superfund problem than it is to spend tax dollars to eliminate problems before the neglected products contaminate the environment. Pesticide collection and amnesty days programs, which previously have been aimed mostly at homeowners, seem to be prudent program dimensions to be instituted on a broader scale basis to avoid problems of superfund proportions.

Pesticide residual waste: Currently some attempts are being made to recycle residual wastes by making use of them in the next load. The utility of this option depends on the operation and its location. For example, if all the major pesticide uses for an applicator are for control of pests on soybeans and corn, this option may be useful as rinse waters may be easily segregated and reused. Where an applicator makes applications to a wide variety of crops there may be problems with phytotoxicity and tolerances associated with the subsequent use of the water on other crops. Under these conditions it may be too costly to segregate all the rinse waters in separate facilities and illegal to use the rinse waters on another crop.

Spilled materials, incompatible mixtures and fire debris: When the material created by these situations is a sizable quantity the current policy requires proper clean up and disposal. Applicators are simply going to have to have good insurance and bite the bullet.

Storm water and runoff: A recently published final rule of EPA will require all applicators to receive a national or state pollution discharge elimination system permit to deal with stormwater removal and runoff from any mixing, loading, holding, storage or disposal site. It means that yet another layer of regulations exists with which an applicator must deal.

STATE RESTRICTIONS

States can be, and generally are, more restrictive than the federal law. Some of the disposal options condoned under the federal law are currently not options available to the end users at the state level; burning of pesticide bags has been prohibited by some states or localities. A number of states have prohibited reuse of containers except when they are triple rinsed and recycled back to the manufacturer or to scrap metal dealers, even though the federal regulations may not have specifically mandated that prohibition. Many states have gone beyond the scope of FIFRA and have implemented rules requiring proper storage of pesticides to minimize any effect on the environment. Although this does not relate directly to waste it is a progressive policy of attempting to assure that unnecessary environmental contamination does not occur from storage sites. In addition there are groundwater concerns in several states; those programs have traditionally been established on a state level.

GROUNDWATER

No disposal paper in 1985 would be complete without some discussions of groundwater contamination. First of all it must be recognized that common law, in general, handles groundwater and surface water in completely separate fashions. Only recently have the courts recognized, in a few cases, that groundwater is not as mysterious as what medieval people might have thought. Although the hydrologic cycle is quite complex there is an interconnection between surface and groundwater. A local flow system occurs in a relatively localized area. Flow is at a faster rate than for a regional flow system and the water generally discharges close by. In a regional flow system recharge of the groundwater can be from some distance way, the water generally is deeper below the surface and travels miles over many years before it discharges.

Long Island, for example, has some regional flow systems that take many hundreds of years from the time of recharge until discharge (Guerrera, 1981). Therefore, if pesticides enter groundwater it may be years later and miles away before the contaminated water actually surfaces, or, for that matter, is tapped for use as groundwater. For that reason it must be recognized that land uses have potentially important impacts on groundwater quality now and into the future.

Since pesticide use may result in the presence of pesticides in groundwater it is extremely necessary to look critically at mixing, loading and handling sites where the potential for the introduction of pesticides from those activities may be increased simply because of the frequency of which pesticides are handled at a site. This increases the need for standards for mixing, loading and handling sites in order to standardize the industry's practices and assure a clean environment.

Water pollution can result from neglect; those circumstances require immediate action both in clean up and in enforcement. It should be recognized, however, that sometimes pesticides get into water on purpose; something that is frequently overlooked in assessing the protection of the environment.

The EPA has recently published a

strategy on how it will conduct groundwater programs. One of the major elements is the coordination between EPA and the states of many program functions. It is very clear that the EPA's intent is for the strategy to have a major impact on all environmental policies regardless of whether they are under FIFRA, SWDA or any other act. The classification of groundwater according to the EPA strategy is of concern. In addition there have been implications that beneficial use of water does not include agricultural use.

The discussions of the presence of pesticides in groundwater has focused rightfully on the health effects associated with exposure. Risk assessments will need to be calculated and health advisories will need to be established if the impact of the presence of a pesticide in groundwater is to be determined. With some idea of the health significance of exposure, adequate management strategies can be proposed to minimize the effect of exposure and, where possible, eliminate the presence of pesticides in groundwater.

SOLUTIONS

Standards must be established for mixing and loading sites; separate standards for dealing with situations that occurred prior to the passage of RCRA and more stringent standards for compliance since the passage of RCRA. Since the law holds people accountable retroactively, current policy suggests a standard of strict liability for past circumstances even when they were done using best available technologies. This creates a lot of fear and disgust on the part of people who are trying, and willing, to comply with the regulations. It certainly has not created a situation with which applicators can easily comply without completely stopping their businesses. They, therefore, do not admit to problems. This does not result in any cleaner environment. A societal desire for actual cleanup must be invented.

One of the solutions to the conflicting policy difficulties may lie in the provision of SWDA which allows for delisting treatment methods. Methods of waste treatment, some of which will be discussed at this conference, haven't been assessed to determine if they can be delisted. Although the original intent of the delisting procedure did not include the assessment of whole categories of potential wastes, such as rinse water, an assessment of whether, and under what conditions, it could be delisted should be pursued.

Land spreading needs more research. One program of EPA condemns it and another condones it. Land spreading does have a real applicability in the pesticide disposal area, however, until a consistent policy is developed this area remains a questionable solution to problems which should be easily resolved. For example, if monitoring wells are required where a pesticide waste is being land spread at low rates, the cost of compliance eliminates the practical use of the option.

Collection of wastes before they become problems must become a societal desire. The prioritization only after major contamination is shortsighted. Incentives which allow more involvement of producers of waste in forming their own destiny would result in a cleaner environment.

A small quantity generators study is due to Congress by April 1985. The study will possibly also assess the farmer exemption. This may provide some relief to small quantity generators or it may not. Regardless, more regulation of small quantity generators will result.

From a research perspective assessments of biological breakdown mechanism has received considerable attention. Papers will be presented at this conference on chemical and physical decompositions as well. Many practices already exist to eliminate problems; some of them are legitimate answers to problems and some are far too expensive. Many, however, are not legal since the regulations or the assessments of the technologies have not kept pace with emerging technologies. There are a number of practical application attempts occurring to properly manage waste on the farm, at applicator sites and in researcher areas. They are not being shared. People are fearful of letting regulators,

tors, researchers or competitors know about them. They are afraid that the practice might be illegal, slightly illegal or not proven beyond a reasonable doubt. Those practices must be brought into the discussions. Methods which have the potential to reduce the threats to the environment must be authorized, if only on an interim basis.

Amnesty programs, where practical, may provide more open discussion and a cleaner environment. There needs to be more discussion with the Hester Fosters in place of fighting with them. Users must do a good job of managing waste. If something happens responsible parties need to react immediately.

SUMMARY

If compliance is easy, it is a good policy. But that statement should not be misinterpreted as meaning that the status quo is good enough. There are costs associated with that policy. Noncompliance with reasonable expectations must result in serious consequences to the offenders. A "less clean" environmental policy cannot be accepted; however, better, more reasonable policies are needed to obtain the desired goal. Changes in policies should provide avenues for assuring minimization of contamination, rather than rhetorical statements of purpose. Once reasonable policies have been established strict enforcement is an absolute necessity.

If the problem of pesticide use versus pesticide disposal were reduced to a simple equation that equation might read: do benefits of pesticide use equal risks of disposal? Hopefully the answer to that is no; benefits of use outweigh the risks of disposal if both use and disposal are done judiciously and properly. All parties must work together and communicate openly if the equation is ever to have legitimate, lasting solutions.

REFERENCES

Alm, A.L., 1985. Hazardous Waste Management System; Dioxin-Containing Wastes, Federal Register 50(9): 1976-2006, January 14, 1985.

Campt, D.D., 1983. Notice to Manufacturers, Formulators and Registrants of Pesticides - Label Improvement Program - Storage and Disposal Label Statement, PR Notice 83-3, USEPA, March 29, 1983. 13 pp.

Cawell, R.L., M.L. Alexander and H. Boyd, 1975. Acceptable Common Names and Chemical Names for the Ingredient Statement on Pesticide Labels, OPP-EPA, Washington, D.C. 181 pp.

Code of Federal Regulations (CFR), 1980. Title 40, Parts 260-265. U.S. Government Printing Office. pp. 892-1006.

Federal Insecticide, Fungicide and Rodenticide Act (FIFRA), as amended in 1978 (7 USC. 136 et. seq.).

Guerrera, A.A. 1981. Chemical Contamination of Aquifers on Long Island, New York. AWWA, April 1981, pp. 190-199.

Guindon, R. 1984. Syndicated Cartoon Character and Cartoon Caption, News America Syndicate, News Group Chicago, Inc.

Hazardous and Solid Waste Amendment of 1984. House of Representatives Report 98-1133, October 3, 1984. 131 pp.

Myrdal, G., 1984. Personal communications on unpublished laboratory studies, DATCP General Labs, Madison, Wisconsin.

Ryan, S.O., 1974. A Study of Pesticide Use, Storage and Disposal in Iowa, Ph.D. Dissertation, Iowa State University, Ames, Iowa as reported in Little, A.D., 1977. Economic Analysis of Pesticide Disposal Methods, U.S. EPA, Washington, D.C. 181 pp.

Schaffer, A. 1985. Unpublished Presentation to the Groundwater Protection and Pesticide Disposal Working Committee of SFIREG. Washington, D.C. January 14-15, 1985.

Solid Waste Disposal Act (SWDA) as amended in 1984 (42 USC. 6901 et. seq.).

APPLICATOR DISPOSAL NEEDS

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ABSTRACT

The state-of-the-art of the mechanical technology available to applicators makes it difficult for compliance with the Resource Conservation and Recovery Act (RCRA). Spray nozzles that leak with optimum maintenance; lack of consistency in the size and composition of pesticide containers; the wide variety of orifices in pesticide containers; the fact that this business is conducted out-of-doors, sometimes after dark, many times away from an applicator's base of operation, and in a wide variety of weather conditions discourages full compliance with the intent of RCRA.

There are inconsistencies throughout the United States in enforcing RCRA. In many states there appears to be minimal or no enforcement. There is need for more uniformity in guidance, regulation, and enforcement associated with pesticide wastes disposal. Development is needed for efficient and cost effective methods of waste disposal techniques for use by applicators. Guidance by the Environmental Protection Agency is required to insure than any major expenditures by application firms will enhance compliance with the law and not subsequently be declared inadequate.

DISCUSSION

Compliance with RCRA is difficult and in some instances impossible for all pesticide applicators. Recommendations are given for mutual cooperation between pesticide applicators and the EPA so that compliance can be achieved over time without causing financial hardship and/or bankruptcies.

Based upon the presentations we have just heard, it is apparent that growers, ground applicators, and aerial applicators of pesticides are probably in violation of many provisions of RCRA and undoubtedly violate this law many times during the spraying season. These repetitive violations of federal law should not be interpreted as a disregard for environmental quality. Instead, the panelists have provided repeated examples of lack of technical ability to come into compliance, a mechanical state of art in their industry which does not enable them to stay in compliance when and if they achieve that objective, and confusion about the regulations and how they apply to all handlers of pesticides.

All spray nozzles available to pesticide applicators will leak if one particle of dirt or sand finds its way into the nozzle. This can and does repeatedly occur with both ground and aeriel applicators. For example, aerial applicators generate large clouds of dust as a result of the prop wash associated with takeoffs and landings. You have learned from a ground applicator that he also generates large amounts of dust while applying pesticides. The very nature of the work environment and the job to be performed guarantees the generation of dust resulting in leaky spray nozzles. Before a mechanic can unplug spray nozzles, he must first rinse them with copious amounts of water so that some of the fine mechanical work, which can only be accomplished with bare hands, can be safely undertaken.

After a spray application, the pesticide residues must be rinsed from the interior and exterior of the application equipment. Under the farmers' tors, researchers or competitors know about them. They are afraid that the practice might be illegal, slightly illegal or not proven beyond a reasonable doubt. Those practices must be brought into the discussions. Methods which have the potential to reduce the threats to the environment must be authorized, if only on an interim basis.

Amnesty programs, where practical, may provide more open discussion and a cleaner environment. There needs to be more discussion with the Hester Fosters in place of fighting with them. Users must do a good job of managing waste. If something happens responsible parties need to react immediately.

SUMMARY

If compliance is easy, it is a good policy. But that statement should not be misinterpreted as meaning that the status quo is good enough. There are costs associated with that policy. Noncompliance with reasonable expectations must result in serious consequences to the offenders. A "less clean" environmental policy cannot be accepted; however, better, more reasonable policies are needed to obtain the desired goal. Changes in policies should provide avenues for assuring minimization of contamination, rather than rhetorical statements of purpose. Once reasonable policies have been established strict enforcement is an absolute necessity.

If the problem of pesticide use versus pesticide disposal were reduced to a simple equation that equation might read: do benefits of pesticide use equal risks of disposal? Hopefully the answer to that is no; benefits of use outweigh the risks of disposal if both use and disposal are done judiciously and properly. All parties must work together and communicate openly if the equation is ever to have legitimate, lasting solutions.

REFERENCES

Alm, A.L., 1985. Hazardous Waste Management System; Dioxin-Containing Wastes, Federal Register 50(9): 1976-2006, January 14, 1985.

Campt, D.D., 1983. Notice to Manufacturers, Formulators and Registrants of Pesticides - Label Improvement Program - Storage and Disposal Label Statement, PR Notice 83-3, USEPA, March 29, 1983. 13 pp.

Cawell, R.L., M.L. Alexander and H. Boyd, 1975. Acceptable Common Names and Chemical Names for the Ingredient Statement on Pesticide Labels, OPP-EPA, Washington, D.C. 181 pp.

Code of Federal Regulations (CFR), 1980. Title 40, Parts 260-265. U.S. Government Printing Office. pp. 892-1006.

Federal Insecticide, Fungicide and Rodenticide Act (FIFRA), as amended in 1978 (7 USC. 136 et. seq.).

Guerrera, A.A. 1981. Chemical Contamination of Aquifers on Long Island, New York. AWWA, April 1981, pp. 190-199.

Guindon, R. 1984. Syndicated Cartoon Character and Cartoon Caption, News America Syndicate, News Group Chicago, Inc.

Hazardous and Solid Waste Amendment of 1984. House of Representatives Report 98-1133, October 3, 1984. 131 pp.

Myrdal, G., 1984. Personal communications on unpublished laboratory studies, DATCP General Labs, Madison, Wisconsin.

Ryan, S.O., 1974. A Study of Pesticide Use, Storage and Disposal in Iowa, Ph.D. Dissertation, Iowa State University, Ames, Iowa as reported in Little, A.D., 1977. Economic Analysis of Pesticide Disposal Methods, U.S. EPA, Washington, D.C. 181 pp.

Schaffer, A. 1985. Unpublished Presentation to the Groundwater Protection and Pesticide Disposal Working Committee of SFIREG. Washington, D.C. January 14-15, 1985.

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exemption to RCRA, it is permissible to apply this rinsate to the farmers' crops. However, after this has been accomplished, one to three gallons of residual rinsate will remain in the spray apparatus. This remaining rinsate solution should be removed from the aircraft before the next spray job in order to avoid cross contamination of pesticides.

Washing the outer surface of ground spray rigs and aircraft at regular intervals is a necessity. During a single washing of one of these pieces of equipment, approximately 80 to 100 gallons of rinsate will be generated. You have learned from the aerial applicator on the panel that this rinsate will contain dirt, oil, hydraulic fluid, insect parts, and pesticides. Utilization of this rinsate as a diluent in the next spray job is impossible since the contaminants would occlude the spray system. During the active spraying season, an applicator will generate thousands of empty pesticide containers. These containers vary dramatically in size, composition, and the toxicity of their contents. The federally approved pesticide label permits disposal of these containers in sanitary landfills after they have been triple rinsed, punctured, and crushed. However, some sanitary landfills refuse to accept these decontaminated pesticide containers. Based upon the formulation originally contained in the pesticide container, it is entirely possible that triple rinsing is not adequate to remove all of the pesticide residue contained therein. Additionally, many of the pesticides are extremely odoriferous and even the triple-rinsed containers generate a pugent organic odor. The strong organic odors eminating from empty pesticide containers labeled with a skull and crossbones can cause a sanitary landfill operator to refuse acceptance. Many pesticide applications occur at night and in the early morning hours before daylight. In many instances, the applicator will be working at a remote site many miles from his base of operation. At these remote work sites, there may be no sources of water and no means of catching and collecting even relatively small volumes of liquid. When work is performed at these remote sites, it is performed under a wide variety of weather conditions, out-of-doors, with only a limited amount of equipment and tools readily available. Attempting to comply with all of the provisions of RCRA is exceedingly difficult under these conditions.

Many operators have asked me what type of construction could be undertaken at the primary site of operation in order to collect and store these various types of pesticide wastes. At the present time, there is no answer for these inquiries since the EPA has not formally approved any type of pesticide collection and storage construction. It would be poor business judgment for any small businessman, such as an applicator, to undertake an expensive construction project with no guarantee that the final result would gain EPA approval. Additionally, if the EPA would disapprove the final construction project after it had been installed and utilized, all of the construction materials would contain pesticide residues and would have to be treated as a hazardous waste, thereby resulting in an extremely expensive disposal project.

In meetings with applicators from across the United States, I have learned that there is no consistency with respect to the enforcement of RCRA. In some states, neither the EPA nor the state agency empowered to enforce RCRA has addressed the issue of pesticide application. In other states, pesticide applicators are only inspected when a formal complaint has been lodged with the responsible agency. In the remaining states, a more active investigation of applicators is taking place. Once an applicator is found by a regulatory agency to be in violation of RCRA, no uniform, economically feasible methods exist for that applicator to come into compliance. In some cases, with which I am personally familiar, the cost of compliance will result in bankruptcy. In other instances, once the applicator has spent the necessary funds to come into compliance, no available technology exists to ensure that the applicator can stay in compliance. Also, the statutory fines imposable against violators under RCRA may be appropriate for multi-national corporations, but become ridiculous when applied to small businessmen, such as applicators.

Since I started my comments by stipulating that all pesticide applicators are probably in violation of RCRA, it appears that the responsible regulatory agencies could, at any time they desire, cite all pesticide applicators for these violations. The resulting cost of compliance and/or penalties imposed would put them out of business, thereby bringing to a halt the great majority of all food and other production in this country. This is obviously an untenable result of enforcement and not the original intent of this Congressional legislation. In order to avoid such a harsh result, research is required to develop efficient and cost effective methods of compliance for pesticide applicators. The EPA and responsible state agencies must give guidance to the pesticide applicators by defining proper methods of dealing with pesticide hazardous waste. Uniformity in enforcement with respect to all pesticide handlers must be established throughout the United States. And before this massive and costly undertaking commences, it would seem prudent that this threshhold question be answered: "Does the use and application of pesticides cause a hazardous waste problem and what is the nature and extent of that problem?"

PESTICIDE WASTES DISPOSAL:
AN AGRICULTURAL AVIATOR'S PERSPECTIVE

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ABSTRACT

In my opinion, the average aerial application firm in the United States is comprised of approximately two pilots and two working aircraft. (Some operators maintain back-up aircraft.) In the Sunbelt, pesticides are applied to approximately 140,000 acres per year, utilizing approximately 50,000 gallons of pesticide. This results in the generation of 4,400 containers each year. These containers are composed of glass, plastic, metal and paper. Container sizes are 1 gallon, 2-1/2 gallons, 5 gallons, 30 gallons, and 55 gallons. The majority of the glass containers are 1 gallon. There is no consistency in the size or shape of caps, bungs, or pouring spouts on most of these containers. In some cases, operators work from bulk storage tanks.

Large volumes of rinsate are generated from the triple rinsing of disposal containers, and the rinsing of hoppers and booms. The washing of the outer skin of the aircraft and other ground support equipment is a problem because such rinsate cannot be used as a diluent for future spray mixtures.

The average applicator's main base of operation may be located on land which he owns or may be on rented land, which in some instances may be located on a public airport.

The aerial application of pesticides is a very competitive business. As a consequence, the price charged for this service has not increased over time at a rate equal to inflation. Payment to the applicator for the services rendered is directly dependent upon the profitability of the farmer/rancher customer. Historically, the farmers'/ranchers' lack of profit or narrow profit margin has made it difficult, if not impossible for commercial applicators to pass on any new costs associated with the handling of hazardous waste.

DISCUSSION

Aerial applicators of pesticides generate pesticide rinsate when triple rinsing empty pesticide containers, rinsing aircraft hoppers and spray booms, washing the outer surface of the aircraft, and from leaks with various couplings and mechanical appliances. Generating the pesticide rinsate and the presence of pesticide leaks occur under optimum operating conditions and with properly maintained equipment.

Any substantial expenditures required to come into compliance with RCRA will cause a severe financial hardship to aerial applicators who are only marginally profitable due to the depressed farm economy.

An aerial applicator is a businessman in a highly technical area handling maybe a hundred toxic pesticide formulations during a single growing season. In addition, an aerial applicator is a pilot who has refined his flying skills so he is capable of flying at night, around and over obstacles, at slow speeds extremely close to the ground. These flying skills are required in order to insure optimum insect eradication while simultaneously minimizing pesticide drift.

I have been an aerial applicator for 35 years. At the present time, the aerial application firm owned by my partner and me applies pesticides for approximately 35 growers. On the average, these growers will have 15,000 acres under cultivation in any one year. My partner and I would apply some material to all of this acreage approximately 10 times each year. These applications would include seeding, fertilizing, pre-emergence herbicides, as well as the application of the entire spectrum of pesticide chemicals. On the average, I would log approximately 500 flying hours per year exclusively doing agricultural work. In those states with a relatively short summer growing season, an aerial applicator would log less flying hours. On the other hand, other applicators in the Sunbelt with long growing seasons might log as much as 700 to 1,000 flying hours per year doing agricultural work.

In my opinion, the average aerial application firm in the United States is comprised of approximately 2 pilots and 2 working aircraft. However, some aerial application firms have only 1 pilot and 1 aircraft. In a few instances, aerial application firms will consist of multiple aircraft and multiple pilots. Some firms may maintain additional back-up aircraft.

In the Sunbelt, an average aerial application firm during a representative spraying season would repetitively apply pesticides to approximately 140,000 acres. This would require the utilization of approximately 50,000 gallons of pesticides. This would result in the generation of 4,400 pesticide containers each year. However, the magnitude of the problem becomes more self-evident when one realizes that in a state such as Arizona there are approximately 70 aerial application firms, each generating 4,400 pesticide containers a year. Therefore, the total number of pesticide containers generated in Arizona per year is approximately 308,000. In addition, each application firm will generate hundreds of empty containers which previously held anti-drift agents, buffer solutions, surfactants, and adjuvants.

Most aerial applicators have no control over the size, shape, and composition of the pesticide containers with which they work. Pesticide containers are composed of glass, plastic, metal and paper. Pesticide containers range in size from one quart, one gallon, 2 gallon, 2-1/2 gallons, 5 gallons, 30 gallons, and 55 gallons. The majority of the glass containers are one gallon. It is extremely difficult to triple rinse all of these containers since some aerial applicators empty the containers into their hoppers at locations extremely distant from their base of operations where no source of rinse water exists. Any effort to mechanize this rinsing operation becomes extremely difficult due to the varying size, shape and container construction. The triple rinsing of these containers as required by federal regulations results in the generation of a substantial amount of rinsate.

Additional sources of large volumes of pesticide rinsate arise from the rinsing of aircraft hoppers and spray booms. Flight safety and maintenance of proper aerodynamics require frequent washing of the outer skin of the aircraft. Again, this results in the generation of large volumes of pesticide rinsate. Less frequently, other ground support equipment must also be rinsed.

Many applicators make an effort to utilize pesticide rinsate as a diluent for future spray mixtures. However, federal law prohibits cross contamination of pesticides; therefore, reutilization of the rinsate is not always possible. Additionally, each pesticide is not registered for application on all crops and the application of a pesticide on a crop for which there is no federal registration or tolerance could result in quarantining and destruction of that crop. Therefore, reutilization of pesticide rinsate is not easily accomplished in all circumstances. Reutilization of pesticide rinsate is impossible when the rinsate contains hydraulic fluid, greases, oils, insect parts, and other foreign matter. This foreign matter would plug up filter screens and nozzles if an attempt were made to use it in future spray mixes.

Other possible sources of contamination by pesticide solutions are as follows:

1. A failure of dry brakes.
2. Plugging of the filter screen.
3. Leaking of rubber diaphragms in the spray nozzles.
4. Rupture of loading hoses and rubber hoses on the aircraft.
5. Failure of hose clamps.
6. Failure of pump seals on the loading equipment or aircraft.
7. Dripping from triple rinsed containers.
8. Draining from dry brake systems after the system has been disconnected from the aircraft.
9. Dripping from the 2" pipe utilized to transfer pesticides from 30 and 55 gallon containers after the pipe has been removed from the empty drums.
10. Leaks from aluminum spray booms on the aircraft.
11. Leaks from plumbing connections and piping on trailers.
12. Human errors in handling all equipment.

These sources of pesticide leaks can occur with optimum equipment maintenance and with the utilization of the best equipment presently available to aerial applicators. These pesticide leaks may cause more concern when the applicator's main base of operation is located on land which is rented or in some instances, is a public airport.

The aerial application of pesticides is a very competitive business. The total number of acres under active cultivation in the United States is decreasing each year. Simultaneously, the number of aerial applicators is decreasing each year. Additionally, farming is not a healthy industry in the United States. In the past years the media and, indeed, the movie picture industry have graphically depicted the rising number of bankruptcies by farmers and foreclosures on farm mortgages. As a consequence, the price charged growers for aerial application services has not increased with time at a rate equal to inflation. In general, the cost of operation for an aerial applicator has increased approximately 300% in the past 10 years. However, the average increase in price charged growers for aerial application services has been only approximately 85% during the same time interval.

Consequently, profitability in the aerial application industry has been progressively decreasing. Many aerial applicators are attempting to sell their businesses. The average age of an aerial applicator in the United States is progressively increasing. There are very few young men being attracted to this industry. Any additional financial burdens placed on aerial applicators in the form of additional regulations, making capital improvements to comply with existing hazardous waste regulations, or the expenditure of large sums of money to eradicate past contamination, may be the final determinate as to whether these businesses will function at a profit or a loss or, indeed, survive at all.

With respect to the existing hazardous waste regulations, it is my opinion that some changes are required to insure adequate food and fiber production for this nation. Some of the changes which would achieve this objective are as follows:

1. A reduction in the daily fines levied on small businessmen, such as aerial applicators, once they are cited for a viola-

tion;

2. Permit aerial applicators to qualify as small waste generators by defining that term as the weight of active ingredient in the waste rather than the weight of the total hazardous waste solution;

3. Permit all aerial applicators to have a grace period to come into compliance with RCRA so that the cost of compliance can be spread over many years of operation rather than a large capital expenditure in a short-time interval;

4. Delegation by the EPA of inspection and enforcement activities to those state and federal agencies who have historically regulated agriculture and aerial applicators thereby gaining, over many decades, an extensive knowledge of pesticides and the agricultural industry.

PESTICIDE WASTES DISPOSAL:
A GROUND APPLICATOR'S PERSPECTIVE

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ABSTRACT

Commercial ground application of pesticides is a growing business in the United States. It is economical for the farmer in terms of time and capital expense. Federal and state authority over pesticide use may also be enhancing the commercial applicator role. In my state, a single unit of ground equipment may apply pesticides and fertilizer to 25,000 acres of Nebraska farmland annually. This involves as many as 30 pesticide products, of which five are restricted and 25 are general use.

During a typical work day a single ground rig can apply 20,000 gallons of spray mix, involving between 250 and 3,000 gallons/pounds of pesticide concentrate. The average volume of spray mix applied per acre is 20 gallons. The operation involves two to three persons on site, including a supply truck with water and chemicals. This work unit will range as far as 50 miles from the home business location, and may be gone for seven or more days before returning.

Generation of pesticide waste, i.e., chemical concentrate of spray mix which will no longer be used as intended, can occur as a result of normal work activity or an accident. Unused spray mix, residue on equipment exteriors, damaged pesticide containers, equipment malfunctions, and accidents are all potential sources of pesticide waste. The equipment and/or facilities used to accumulate and contain pesticide waste is an individual applicator decision. Federal/state statutes and regulations merely tell pesticide applicators what may not be done with pesticide waste.

DISCUSSION:

The pesticides that I apply are all intended for use on cropland. Soil in the treatment site can be moved to non-target areas via vehicle tires, worker boots and clothing, equipment exteriors, and wind or water erosion. It seems to me that such transfers from the target site could be a technical violation of solid waste disposal regulations and perhaps FIFRA too.

Water is seldom available at spray sites so I use nurse rigs to carry water for preparing spray mix. It takes 200 gallons or more to flush the hopper of a Big A spray rig. Farmers do not like this rinsate applied to the crop just treated because of additional soil compaction. If the next job site requires a different pesticide and the previous pesticide was not labelled for use on the second crop, storage of the rinsate becomes a serious handling problem.

Commercial and private applicators need assistance in developing affordable and nationally approved methods for handling and/or disposing of pesticide wastes. Such methods should be acceptable for time periods of sufficient duration to offset initial and continuing expense.

How much can a pesticide applicator afford to spend on proper handling and disposal of hazardous waste? This question is unanswerable until we know what will be approved. Many applicators who tried to anticipate what would be acceptable already have wasted thousands of dollars. Compliance with the law and the regulations cannot occur until all questions are answered.

Also, remember that whatever becomes required will be needed by commercial and private applicators alike. Both user groups work over the same aquifers and near the same rivers, lakes, streams, etc. Conditions at the pesticide storage and mix-load sites are relatively common. Spills and container disposal that occurred in the 1950's or last month all have the potential for creating a detectable pesticide presence in a non-target site.

Obviously, the best way to avoid the problem is to eliminate the generation of waste. Failing that, instead of hauling waste all over the country to approved disposal sites, perhaps industry could develop soil and spray tank additives that would neutralize such wastes. Soda ash, lime, and activated charcoal may be an easy solution to some of our current problems.

As we all strive to reduce waste generation, perhaps a moritorium should be declared on enforcement activities to everyone. Perhaps existing laws and regulations should be amended for the same reason.

Today, there are too many regulatory groups addressing the same problem. A single waste generator may be compelled to deal with a Department of Health, a drinking water agency, a Department of Environmental Affairs, the Department of Agriculture, the Department of Transportation, and other subdivisions of government at both state and federal levels. Our business is agriculture. Maybe everyone who wants to tell us how to run our businesses should coordinate their needs through the Department of Agriculture. We have worked within the USDA system for years. They know us and our work and we know who to call for help. Let's consolidate everyone's need all in one place.

Finally, let's meet again one year from now. Let's find out if you were able to solve some of our problems and whether or not we as applicators were able to reduce the amount of waste generated and handled in a better manner.

PESTICIDE WASTES DISPOSAL:
A PRIVATE APPLICATOR'S PERSPECTIVE

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The scope of the "on the farm" disposal problem fits into the following parameters:

On the positive side--of 100,000 farming operations in Illinois, no fatalities have resulted from farmer application or disposal of agricultural chemicals in the past five years.

Of these 100,000 operations, an average of two complaints are filed per year due to improper farmer activities such as dumping chemicals or washing out a sprayer tank along a stream resulting in fish kills.

Five to six complaints per year arise from improper disposal of chemical containers.

On the negative side--a study found that approximately 40 percent of farm wells in Illinois suffer from some form of contamination. While this contaminaion arose mainly from bacterial sources due to improperly capped wells; in a significant number of cases, pesticides were found. The primary source of these pesticides were considered by the researchers to be from chemical mixing and disposal operations at the well.

Also a simple visual inspection of most farmsteads will produce at least one example of improper chemical disposal from a dead patch of grass in the yard to empty chemical containers in the tool shed.

The Illinois EPA ranks farm chemical disposal problems it perceives as: 1) disposal of obsolete or frozen product, 2) disposal of tank rinsates, and 3) disposal of chemical containers.

This presentation is aimed at pesticide users who generate or transport a hazardous waste and who must comply with federal hazardous waste management standards. The purpose is to give these people a basic understanding of the regulatory requirements and enforcement ramifications.

FEDERAL REGULATION OF PESTICIDE DISPOSAL

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ABSTRACT

There are many questions about the regulation of pesticide disposal in the minds of pesticide users. Considerable confusion exists about the EPA regulation of pesticide disposal. To further complicate the issue, State laws have become increasingly stringent and prevail in many cases. One reason for all of this uncertainty is the lack of a clear understanding of the two Federal laws administered by EPA. The laws are the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and the Resource Conservation and Recovery Act (RCRA). Regulations promulgated under these two legislative acts, particularly RCRA, are quite comprehensive and in a state of continual change. Each of the two laws have a place in the overall system of regulating pesticide disposal. The objective of this discussion is not so much to present an in-depth discussion of the regulations on pesticide disposal but to introduce the pesticide user to those parts of FIFRA and RCRA relating to management of pesticide-containing wastes that might be generated in the course of using pesticides. Therefore, only the key issues will be addressed.

FEDERAL INSECTICIDE, FUNGICIDE, AND RODENTICIDE ACT

Pesticides were first regulated in 1910, pre-dating Federal regulation of food for human consumption by several years. Comprehensive regulation of pesticide use did not occur until the Congress passed the Federal Insecticide, Fungicide, and Rodenticide Act of 1947. Until passage of the 1972 amendments, little or no attention was given to the problem of safe disposal. Prior to the 1972 amendments the main concern was an accurate label statement. Given the interest in protecting the environment shown in the late 1960's and 1970's, the 1972 amendments directed the EPA to consider the potential effects on the environment in registering the use of a pesticide. These amendments included specific clauses related to pesticide disposal by directing the EPA Administrator to publish regulations and procedures covering the disposal of pesticide wastes. More recent amendments require disposal instructions to be included with any cancellation notices issued. The basic control of the use of a pesticide through FIFRA is by way of the premarket clearance of a proposed use and the EPA-approved instructions to the user that appear on the label. Since FIFRA says it is a violation of Federal law to use a pesticide in a manner inconsistent with its labeling, compliance with the label directives becomes mandatory. Regulations that have been issued under the authority of FIFRA require that disposal statements appear on the label.

The statements that appear on the container label generally address disposal of the container itself. However, information on disposal of the formulated product is sometimes included. More comprehensive advisory information may be supplied by the producer of the product. EPA has provided guidance on disposal labeling to pesticide producers in Pesticide Registration Notice: 83-3, (PR Notice 83-3) specifying what the disposal statement must cover. More recently EPA published PR Notice 84-1 which up-dates and amends PR Notice 83-3.

These notices require that all products bear specific label instructions covering storage and disposal and that the information be grouped together in the "Directions for Use" portion of the label under the heading "Storage and Disposal". Although all product labels are required to have appropriate storage instructions specific statements are not prescribed. Each registrant must develop his own statement considering the factors listed in PR Notices 83-3 and 84-1.

For purposes of disposal labeling, wastes from pesticide products that are intended for household use are treated as non-hazardous wastes by PR Notice 83-3. Many of the pesticide products that are intended for use in public areas such as office buildings, retail stores, hotels, schools, and hospitals, do not result in hazardous waste when discarded and will bear a label statment on disposal that is the same as that which appears on a household product. However, some of these products are RCRA regulated waste when discarded and are required by PR 83-3 to show a label statement reflecting that fact. It must be noted that RCRA does not regulate household wastes, however, wastes from hospitals, schools and the like may be subject to Federal or State hazardous waste rules. The statement "Do not reuse container (bottle, can, bucket). Wrap (container) and put in trash" must appear on all products registered for household use or other domestic use products that do not result in a RCRA regulated waste when discarded that are sold in containers of one gallon or less for liquids (except for bleach products up to 1-1/2 gallons) and 5 pounds or less for dry material (except for lawn fertilizer herbicide products up to 25 pounds). In addition, PR Notice 83-3 provides container disposal statements for these products based on container type.

The instructions for household/domestic products are based on the determination that these products, in limited quantities, do not pose a threat to human health or the environment. The dilution factor is so large that small amounts of these relatively non-toxic materials will not create a hazard. On the other hand, acutely toxic material of any kind should never be placed in the trash. To do so could endanger the workers that collect the trash.

Products that contain active ingredients appearing on the "Acutely Hazardous Commercial Chemical Products List" (RCRA E List) or are assigned to Toxicity Category I on the basis of oral or dermal toxicity, skin or eye irritation potential, or Toxicity Category I or II on the basis of acute inhalation toxicity must bear the following statement: "Pesticide wastes are acutely hazardous. Improper disposal of excess pesticide, spray mixture, or rinsate is a violation of Federal law. If these wastes cannot be disposed of by use according to the label instructions, contact your State Pesticide or Environmental Control Agency, or the Hazardous Waste representative at the nearest EPA Regional Office for guidance." Products on RCRA's Commercial Chemical Products list (40 CFR §261.33(e)) would be subject of regulation if a generator produced more that one kilogram or more of such waste per month. There are exceptions where much lower levels of these products are regulated as in the case of products that contain dioxins.

The labels of all products, except those intended for household/domestic use, containing active or inert ingredients that appear on the "Toxic Commercial Products List" (RCRA F List) or meet any of the criteria in RCRA Subpart C, 40 CFR 261 for a hazardous waste, must bear the same statement. Labels for all other products, except those intended for household use, must bear the following pesticide disposal statement: "Wastes resulting from the use of this product may be disposed of on site or at an approved waste disposal facility." Required container disposal statements are shown in Table 1.

It should be noted that the terms used in disussing the RCRA regulations that relate relate to hazard, such as "Acutely Hazardous" or "Toxic Commercial Products", have different meaning from the same terms used in the FIFRA regulations. The reason is that different criteria used to establish the hazard level.

RCRA

The Resource Conservation and Recovery Act may appear to be burdensome, complicated, and unnecessary to many pesticide users. However, when the basic Objectives of the legislation are considered, the regulatory system makes good sense. Protecting human health and the environment from the insults of mismanaged waste is a basic need of modern society. The pesticide user need not be concerned with much of the regulatory structure, unless he plans to establish on-site disposal operations. However, there are some basic requirements of RCRA that are important to the pesticide user.

To understand RCRA regulations it is necessary to start with a definition of what is regulated. In short, RCRA is intended to regulate the management of all solid waste. The term "solid waste" means any waste; liquid, sludge, dry, or anything in between that is disposed of, burnt, or recycled (with several exceptions). A waste is defined as any material that is intended to be discarded or has served its useful purpose, regardless if the material is to be disposed of, re-used, or recycled. Since the most stringent regulations are directed at the control of wastes identified as "hazardous wastes", it is most important to the pesticide user to be aware of the status of any material that becomes a "solid waste". A solid waste is a hazardous waste if it exhibits any of the characteristics of a hazardous waste:
(1) ignitability, (2) corrosivity,
(3) reactivity, and (4) toxicity
(40 CFR §§261.21 261.24), or is listed in the RCRA regulations (40 CFR §§261.31, 261.32, 261.33). Pesticide wastes are also considered hazardous if they exhibit any of the following characteristics:

- are solvent based and have a flash point of less than 60° C,
- are aqueous and have a pH less than 2.0 or greater than 12.5,
- release HCN or H_2S upon contact with acids,
- leach greater than threshold levels of one or more of the elements arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver
- the pesticides endrin, lindane, methoxychlor, toxaphene, 2,4-D, or 2,4,5-TP (Silvex)

Most of the pesticides that are currently listed on the RCRA "E" or "F" lists are shown in Table 2. These lists, prepared in October of 1984, should not be considered the final word in that they are under almost continual change. Additional guidance can be found on the pesticide product label. Pesticides that meet the hazardous waste criteria will usually bear a disposal statement on the label that reads in part: "Pesticide wastes are acutely hazardous" or "Pesticide wastes are Toxic". In some cases, it may be necessary to obtain professional technical assistance in making the determination that a given material is indeed a hazardous waste. Some sources of such information are given later in this paper.

Part of the confusion that arises from identifying hazardous waste comes from the way RCRA handles mixtures. For example, wastes from pesticide formulations that contain more than one active ingredient are not currently regulated (there are exceptions to this that are explained later). On the other hand, single active ingredient products that contain pesticides listed in Table 2 (from the RCRA "E" and "F" lists) are regulated hazardous wastes when disposed of unused. Other sources of regulated wastes containing single ingredient products might be left-over tank mixes, empty containers that have not been rinsed for "E" list wastes or unrinsed containers with over an inch of chemical for "F" list wastes, spill residues, or wash water from cleaning out equipment containing "E" list wastes. However, if there is more than one active ingredient in the formulation and if one or even all of the active ingredients appears on the "E" or "F" list, then the formulation is not regulated as a RCRA listed hazardous waste. There are regulations under development that will eventually regulate mixtures that contain "E" and "F" chemicals on the basis of toxicity.

Once a waste material has been designated as RCRA hazardous waste as a single active ingredient product as discussed above, then RCRA has a mixture rule that prohibits designated or listed wastes from just being diluted or mixed in order to dispose of them. This means that mixing two listed waste streams together will not exempt the mixture from regulation.

An exception to the rule that exempts pesticides that contain more than one active ingredient, one of which is listed, involves the characteristics of the waste. Even if the pesticide residues are not RCRA "E" or "F" sole active ingredient listed wastes, they may be hazardous on the basis of the following characteristics: ignitable, corrosive, reactive, or EP toxic In that case, although there may be more than one pesticide in the regulated mixture the rule for mixtures of listed waste does not apply. The waste is only hazardous as long as it exhibits the characteristic and the characteristic may be due to one of the inert ingredients in the formulation. Of course, if the generator produces regulated quantities of pesticides, then the act of mixing that renders the hazardous waste non-hazardous is considered treatment. Treatment is subject to further regulation, including permitting that covers operating procedures, inspections, and so on. If a generator decides to render waste non-hazardous on site, then he must make sure he understands all the regulations that apply.

In summary, mixing RCRA "E" or "F" listed wastes that are sole active ingredients will result in a mixture of listed wastes still subject to regulation. Mixing characteristic wastes may actually serve to render the waste non-hazardous, but the act of mixing may be subject to RCRA regulation.

Mixtures involving a pesticide which is performing its intended function, such as fungicide-treated seeds, are not regulated as commercially unused RCRA listed waste, because the pesticide has already been applied to serve its intended purpose.

It should be noted that not all pesticide-containing wastes are "hazardous wastes" regulated by RCRA requirements, but those that are, should be the focus of serious attention for the user. There are regulatory requirements for storage, transportation, treatment, and disposal of all such wastes along with some severe penalty in the event of a violation. When a pesticide user produces more than the amount established as a minimum exemption level by EPA of RCRA regulated waste materials he becomes subject to applicable generator and other RCRA regulations. In the case of wastes listed in §261.33(e) of RCRA (the RCRA E list), the lower limit may be as little as 1 kilogram per month. The upper limit currently is 1,000 kilograms per month, however, recent congressional amendments to RCRA mandate control at the 100 kilogram per month level. This means that about 100,000 Small Quantity Generators (SQGs) of all kinds will come under the RCRA regulations for some aspects of hazardous waste management. Under RCRA, generators must meet many special requirements such as notification of hazardous waste activity, obtaining an EPA identification number, shipping wastes only by registered waste haulers that are subject to hazardous waste regulations, including the use of the uniform manifest.

The lowering of the SQG exemption level will take effect in August of 1985, but the final regulatory program has not been completed. The 100 kilogram level will bring many others into the ranks of the regulated community, including auto repair and painting shops, printers, engravers, ceramics producers, dry cleaners and others. Aerial applicators may find that their airframe and engine maintenance shops are also Small Quantity Generators. A training program to inform the newly regulated SQGs of their responsibilities under the new rules is a basic part of current EPA planning. As is always the case, available resources will be a governing factor in determining how extensive such a program can be.

REGULATION OF USERS OF HOME AND GARDEN OR DOMESTIC PRODUCTS

Household wastes are not regulated under RCRA, since they are specifically excluded (40 CFR 261.4). As is the case in the use of any pesticide, it is most important that the user read the label. The label will provide information on precautions that must be observed and directions for disposal of the empty container. Because of the small quantities of residue left after product use and the generally low toxicity of these kinds of products, the empty containers, as well as small amounts of the pesticide materials themselves, may be wrapped in several layers of paper, or otherwise packaged and disposed of in the trash collection. The purpose of the wrapping or extra packaging is to confine the material during compaction so that unnecessary exposure does not occur. Up to one (1) gallon of liquid pesticides (1-1/2 gallons of disinfectants) may be safely disposed of in this manner. The maximum limit for dry pesticide materials is five pounds or in the case of fertilizers that contain small amounts of herbicide, 25 pounds. Occasionally, a homeowner is found to have something like a five gallon can of parathion that was given to him by a well-meaning friend or relative to "take care of those aphids on the roses" such materials should never be placed in the municipal trash collection. For disposal of such toxic material, the homeowner should seek professional help.

REGULATION OF FARMERS

The use of pesticide products on the farm can result in the production of wastes which may be "RCRA" hazardous wastes. However, a farmer is exempt from the generator requirements of RCRA provided he triple-rinses his empty containers or rinses them using a method of equivalent effectiveness, and disposes of the pesticide residues on his own farm in manner consistent with the disposal instructions on the pesticide label (40 CFR 262.51). This exemption is quite narrow and quite specific. What it means is that left over tank mixes and wash waters can be sprayed over an area allowed by the label directions, such as the margins of the field where the product was used or can be used as make-up water in the tank mix. It does not mean that a farmer is allowed to bury or dump waste pesticides anywhere on his property.

REGULATION OF COMMERCIAL APPLICATORS

Commercial applicators do not enjoy an exemption as do farmers. All wastes produced should be evaluated considering the pesticide material present, asking the question: "Is this a hazardous waste?" Left over tank mixes, empty containers that have not been properly rinsed, unusable products, or wash water from cleaning spray equipment may be a hazardous waste regulated under RCRA. Generating more than 100 kilograms per month of regulated wastes will qualify the applicator as a "generator". In any event, all hazardous wastes must be disposed of in a permitted facility, or in some cases for small quantity generators, at State-approved municipal or industrial facilities. On site treatment, storage, and disposal facilities (such as the familiar evaporation pond) must have RCRA permits, and the requirements for hazardous waste permits are extensive. Also consider that the 100 kilograms per month limit is reached when one 55-gallon drum is a little over half full of a hazardous waste. In addition, disposal of one full drum by a commercial disposer of hazardous wastes could cost as much as $3,000. All of this would appear to present the commercial applicator with a difficult, almost hopeless situation, squarely facing a loss in the never ending battle of keeping the sale price of competitive services from being over taken by the cost of operation and becoming, by default, a non profit organization. Happily, the situation is not hopeless. There are ways of addressing the problem.

STRATEGIES FOR OPERATING UNDER FEDERAL REGULATION

First of all, the pesticide user must learn what pesticide products will result in wastes regulated as "hazardous wastes" under RCRA. Wastes that contain any one of the many pesticide products that, for one reason or another, are not classed as "hazardous wastes" are simply non-hazardous solid waste which is also known as "garbage" or "trash". EPA has not as yet seen fit to regulate this type of waste.

All users of pesticides are constantly reminded to read the label. This is important in assuring safe and effective use of the product, as well as assuring proper disposal. Users should always be familiar with the disposal instructions and precautions that appear on the label. In the case of farmers and homeowners, this is particularly important. Users of pesticides should make every effort to eliminate the production of any waste, especially "hazardous wastes", and there are ways of doing just that. For example, rinse all empty containers and add the rinse solution to the spray mix. This not only eliminates the concern over disposal of the empty container as a hazardous waste, but also saves the user money by utilizing every last drop of what is often a very expensive material. Liquids from equipment washdown or container rinses can often be sprayed out on the target area or on the field margins. In this case the label directions for use must be carefully observed. Rinse and/or wash solutions may be put in tanks and held for future use as diluents in spray mixes of products of the same type. Obviously, care must be exercised to keep incompatable materials separated. Again, the label directions can serve as a guide. Careful management of inventories and tank mixes will not only serve to minimize production of waste, but will also save money. A little extra care in ordering a pesticide can often eliminate that half bag or gallon or two left over that can not be used. If it can not be used, it is a solid waste. The same is true of tank mixes. Mix only what is needed for the job. There is nothing new here. These strategies have been around since there have been pesticides. The only thing different is that eliminating waste has taken on a new meaning.

If it becomes necessary to dispose of a small quantity of a "hazardous waste", the services of a commercial hazardous waste disposal firm may be required. Unfortunately, the larger commercial operations are generally not interested in small amamounts, especially when the material for disposal is many miles from the nearest disposal facility. It may be possible to arrange for "milk run" pick-ups in conjunction with other small quantity generators. Pooling wastes for disposal through local cooperatives may also be a possibility, as long as incompatible materials are not combined. Manufacturer/distributor return services should be explored. Bear in mind that the local auto repair shop and the neighborhood dry cleaner may also be SQGs. Local waste collection sites or transfer stations might also be considered.

Extensions to the time limit that generators may hold their waste without a storage permit have been mandated by Congress. These extensions raise the present 90 day limit to 180 days and to 270 days for SQGs shipping their waste over 200 miles. In this way pesticide users with hazardous wastes will be allowed to accumulate a more economical amount for shipment, if necessary.

The pesticide user should learn what facilities and services are available in the local area for the management of hazardous wastes. Information of this kind is generally available from the agency responsible for enforcement of waste management regulations for the area.

Many pesticide users are "Certified Applicators". This title is needed to obtain authorization to buy and to apply restricted use pesticides. To achieve certified status, the applicator must learn how to safely and effectively apply pesticides and demonstrate a knowledge of the regulations. Now that hazardous waste disposal is also regulated, the pesticide user, regardless of certification status, is well advised to extend his knowledge to include the regulations that cover storage and disposal of pesticide wastes in the local area. Since many States have more stringent rules than those discussed here, it is most important to contact the State or local hazardous waste regulatory agency. Each EPA Regional Office has a hazardous waste representative that may be able to help. Another source of information on waste management is the RCRA Hot Line. A trained staff is available to answer a wide range of questions on the subject. The Hot Line number is 800-424-9346. For pesticide users that are also small businessmen, the EPA Small Business Ombudsman is available to provide assistance. The Small Business Hot Line telephone number is as follows: 800-368-5888. There are many other sources of information such as trade organizations, cooperatives, and the many publications available to users of pesticide products.

TABLE 1

CONTAINER DISPOSAL STATEMENTS

Container Type	Disposal statement
Metal containers	Triple rinse (or equivalent). Then offer for recycling or reconditioning, or puncture and dispose of in a sanitary landfill, or by other approved State and local procedures.
Plastic containers	Triple rinse (or equivalent). Then offer for recycling or reconditioning, or puncture and dispose of in a sanitary landfill, by incineration or, if allowed by State and local authorities, by burning. If burned, stay out of smoke.
Glass containers	Triple rinse (or equivalent). Then dispose of in a sanitary landfill, or by other approved State and local procedures.
Fiber drums with liners	Completely empty liner by shaking and tapping sides and bottom to loosen clinging particles. Empty residue into application equipment. Then dispose of liner in a sanitary landfill or by incineration if allowed by State and local authorities. If drum cannot be reused[1], dispose of in the same manner.
Paper and plastic bags	Completely empty bag into application equipment. Then dispose of bag in a sanitary landfill, by incineration or, if allowed by State and local authorities, by burning. If burned, stay out of smoke.
Large compressed gas cylinders	Return empty cylinder for refilling (or similar wording).

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[1] Manufacturer may replace this phrase with one indicating whether and how fiber drum may be reused.

TABLE 2

PESTICIDE ACTIVE INGREDIENTS THAT APPEAR ON THE RCRA "ACUTELY HAZARDOUS COMMERCIAL PRODUCTS" LIST (THE RCRA E LIST)

Acrolein
Aldicarb
Aldrin
Allyl alcohol
Aluminum phosphide
4-Aminopyridine
Arsenic acid
Arsenic pentoxide
Arsenic trioxide
Calcium cyanide
Carbon disulfide
p-Chloroaniline
Cyanides (soluble cyanide salts)
Cyanogen
2-Cyclohexyl-4,6-dinitrophenol
Dieldrin
O,O-Diethyl S-[2-ethylthio)ethyl] phosphorodithioate
  (disulfoton, Di-Syston®)
O,O-Diethyl O-pyrazinyl phosphorothioate (Zinophos®)
Dimethoate
O,O-Dimethyl O-p-nitrophenyl phosphorothioate
  (methyl parathion)
4,6-Dinitro-o-cresol and salts
4,6-Dinitro-o-cyclohexylphenol
2,4 Dinitrophenol
Dinoseb
Endosulfan
Endothall
Endrin
Famphur
Fluoroacetamide
Heptachlor
Hydrocyanic acid
Hydrogen cyanide
Methomyl
alpha-Naphthylthiourea (ANTU)
Nicotine and salts
Octamethylpyrophosphoramide (OMPA, schradan)
Parathion
Phenylmercuric acetate (PMA)
Phorate
Potassium cyanide
Propargyl alcohol

TABLE 2 RCRA E List (continued)

Sodium azide
Sodium cyanide
Sodium fluoroacetate
Strychnine and salts
0,0,0,0-Tetraethyl dithiopyrophosphate (sulfotepp)
Tetraethyl pyrophosphate
Thallium sulfate
Thiofanox
Toxaphene
Warfarin
Zinc phosphide

There are currently no inert pesticide ingredients on the RCRA "E" list.

TABLE 2

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PESTICIDES AND INERT PESTICIDE INGREDIENTS CONTAINED ON THE RCRA " TOXIC COMMERCIAL PRODUCTS LIST (RCRA F LIST)

Active Ingredients

Acetone
Acrylonitrile
Amitrole
Benzene
Bis(2-ethylhexyl)phthalate
Cacodylic acid
Carbon tetrachloride
Chloral (hydrate)
Chlordane, technical
Chlorobenzene
4-Chloro-m-cresol
Chloroform
o-Chlorophenol
4-Chloro-o-toluidine hydrochloride
Creosote
Cresylic acid (cresols)
Cyclohexane
Cyclohexanone
Decachlorooctahydro-1,3,4-metheno-2H-cyclobuta[c,d]-pentalen-2-one
    (Kepone, chlordecone)
1,2-Dibromo-3-chloropropane (DBCP)
Dibutyl phthalate
S-2,3-(Dichloroallyl diisopropylthiocarbamate) (diallate, Avadex)
o-Dichlorobenzene
p-Dichlorobenzene
Dichlorodifluoromethane (Freon 12®)
3,5-Dichloro-N-(1,1-dimethyl-2-propynyl) benzamide (pronamide, Kerb®)
Dichloro diphenyl dichloroethane (DDD)
Dichloro diphenyl trichloroethane (DDT)
Dichloroethyl ether
2,4-Dichlorophenoxyacetic, salts and esters (2,4-D)
1,2-Dichloropropane
1,3-Dichloropropene (Telone)
Dimethyl phthalate
Epichlorohydrin (1-chloro-2,3-epoxypropane)
Ethyl acetate
Ethyl 4,4'-dichlorobenzilate (chlorobenzilate)
Ethylene dibromide (EDB)
Ethylene dichloride
Ethylene oxide
Formaldehyde
Furfural

Table 2 RCRA F List (continued)

Hexachlorobenzene
Hexachlorocyclopentadiene
Hydrofluoric acid
Isobutyl alcohol
Lead acetate
Lindane
Maleic hydrazide
Mercury
Methyl alcohol (methanol)
Methyl bromide
Methyl chloride
2,2'-Methylenebis (3,4,6-trichlorophenol) (hexachlorophene)
Methylene chloride
Methyl ethyl ketone
4-Methyl-2-pentanone (methyl isobutyl ketone)
Naphthalene
Nitrobenzene
p-Nitrophenol
Pentachloroethane
Pentachloronitrobenzene (PCNB)
Pentachlorophenol
Phenol
Phosphorodithioic acid, 0,0-diethyl, methyl ester
Propylene dichloride
Pyridine
Resorcinol
Safrole
Selenium disulfide
1,2,4,5-Tetrachlorobenzene
1,1,2,2-Tetrachloroethane
2,3,4,6-Tetrachlorophenol
Thiram
Toluene
1,1,1-Trichloroethane
Trichloroethylene
Trichloromonofluoromethane (Freon 11®)
2,4,5-Trichlorophenol
2,4,6-Trichlorophenol
2,4,5-Trichlorophenoxyacetic acid (2,4,5-T)
2,4,5-Trichlorophenoxypropionic acid (Silvex)
Xylene

INERT PESTICIDE INGREDIENTS APPEARING ON THE TOXIC COMMERCIAL PRODUCTS LIST (RCRA F LIST)

Acetone
Acetonitrile
Acetophenone
Acrylic acid
Aniline
Benzene
Chlorobenzene
Chloroform
Cyclohexane
Cyclohexanone
Dichlorodifluoromethane (Freon 12®)
Diethyl phthalate
Dimethylamine
Dimethyl phthalate
1,4-Dioxane
Ethylene oxide
Formaldehyde
Formic acid
Isobutyl alcohol
Maleic anhydride
Methyl alcohol (methanol)
Methyl ethyl ketone
Methyl methacrylate
Naphthalene
Saccharin and salts
Thiourea
Toluene
1,1,1-Trichloroethane
1,1,2-Trichloroethane
Trichloromonofluoromethane (Freon 11®)
Vinyl chloride
Xylene

CALIFORNIA REGULATORY REQUIREMENTS

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Pesticide wastes disposal is regulated in California by the Department of Health Services (DHS), the Water Quality Control Boards (WQCBs), and the Department of Food and Agriculture (DFA). DFA regulations establish a generic performance standard that pesticides (including wastes) shall not be stored, handled or disposed of in a manner which may present a hazard to persons, animals, food, feed, crops, or property, and establish specific standards for rinsing of containers and posting of storage areas. WQCB regulations require that waste discharge requirements be obtained where a discharge or potential discharge exists which threatens water quality. These requirements generally consist of water monitoring programs and design and construction requirements to prevent any degradation of water quality. The WQCBs have the primary responsibility where water quality is threatened, however, the DHS is the lead agency with regard to hazardous waste control and will act to correct any environmental threat from hazardous waste. DHS regulations establish specific construction and operating standards for hazardous waste handling, treatment, storage and disposal and establish criteria for determining whether or not a waste is hazardous. A waste is regulated as hazardous if it consists of or contains a material cited in a regulatory list or if it meets specific regulatory criteria. The list contains many pesticides and includes the generic categories of insecticides, unrinsed pesticide containers, unwanted or waste pesticides, and weed killer. Hazardous wastes generators, treaters, storers, transporters, and disposers have specific regulatory requirements which they must conform to or obtain a variance from. The DHS, WQCBs, and DFA strive to work closely together to minimize the potential of conflicting or duplicative regulations. The proper management of pesticide wastes should be a major consideration of pesticide users. The cleanup costs and potential civil and criminal penalties are so great that the long term cost of improper management far exceeds any short term savings.

PESTICIDE DEGRADATION PROPERTIES

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ABSTRACT

Pesticide waste disposal is a significant problem for the agricultural applicator. Understanding the properties of the ca. 680 pesticide active ingredients used in American agriculture is useful in developing an effective disposal scheme. In reality, less than 30 active ingredients make up more than 90% of the pesticides used annually on approximately 300 million acres of major U.S. field crop acreage. Persistence and mobility in the environment are two of the most useful properties of a pesticide. These two properties are especially important when one is considering any form of land disposal system, the most widely used and economical option available to the user. Persistence increases the probability of movement, although persistent pesticides are not necessarily mobile. Movement of a waste pesticide by volatilization into air or leaching through soil into groundwater must be avoided. Therefore, containment and degradation are important features in the design of any waste treatment facility. Three additional criteria that must be met by any disposal option for the average user are the legal, economic, and practical aspects. From an economic standpoint, the technology that manufacturers of chemicals use to handle large volumes/low concentrations of wastewater is often too expensive to be feasible for the agricultural applicator. On the other hand, the cost of pesticide degradation at the user level is small compared with the astronomical costs associated with cleanup at a waste site. The persistence and mobility patterns of the most widely used herbicides and insecticides will be considered in detail, along with some economic aspects of disposal.

INTRODUCTION

In organizing this workshop we agreed to consider practical approaches to waste disposal and not to get into complex equations, sophisticated models, or physical and chemical constants in selecting a process. One problem is that there are no simple constants available for all pesticides that fully apply to all of the options being considered for waste disposal. In other words, you can't consult an encyclopedia to find a universal disposal constant.

A second problem is the large number of compounds that make up the pesticide family. One estimate suggests that there are 680 pesticide active ingredients currently used in American agriculture. Theoretically, any such universal disposal parameter would have to be developed for each pesticide. Our problems are simplified, however, because less than 30 active ingredients account for more than 90% of the pesticides used annually.

For evaluating waste disposal methods, two of the most important practical properties of a pesticide are its persistence and mobility in the environment. These properties are especially important considerations in land disposal, which is the most widely used and economical option available to the user. Persistence and mobility are also important considerations in spill situations, abandoned waste sites, or in disposal processes that lead to incomplete destruction or binding of the pesticide and its subsequent release in the environment. One possible consequence of a poorly designed disposal process is groundwater contamination. For the groundwater issue, it is also necessary to understand the persistence and mobility of the pesticides to be disposed.

Persistence reflects the rate at which the sum total of all processes degrade a molecule in the environment, including oxidation, reduction, or hydrolysis. Most disposal options are usually an intensified form of one of these processes. An understanding of the processes that affect persistence and mobility of a pesticide in the environment also gives some clue as to the possible choice of a disposal option. For example, most persistent compounds are generally not readily biodegradable; therefore, biological treatment is not a viable method of disposal. Progress in molecular biology eventually may provide engineered microorganisms capable of metabolizing these more recalcitrant structures, but gene manipulation research in our own laboratory suggests that progress here will be slow and costly. Movement of a waste pesticide by volatilization into the air or leaching through soil into groundwater must be avoided. Therefore, economical containment and degradation are two important features in the design of any waste treatment facility.

PURPOSE

The objective of this paper is to review current knowledge regarding pesticide persistence and movement and the impact of these processes on waste disposal. Some economic consequences of waste disposal will also be considered. The herbicides and insecticides most widely used in American agriculture that will be considered are shown in Table 1.

PERSISTENCE

First, the persistence of these same 20 pesticides and waste disposal will be considered. Specifically, the effect of concentration on pesticide persistence in a land disposal option will be examined.

Bar graphs were developed in a previous publication (4) to depict the time required for 90% of added pesticides to disappear from soil environments. These graphs dealt with chemical classes of pesticides and were derived from persistence data available at that time. The data used to develop these bar graphs come largely from field studies where normal

TABLE 1. TEN MOST WIDELY USED HERBICIDES AND INSECTICIDES

Herbicides		Insecticides	
Common Name	Trade Name	Common Name	Trade Name
alachlor	Lasso	carbaryl	Sevin
atrazine	AAtrex	carbofuran	Furadan
butylate	Sutan	chlorpyrifos	Dursban
trifluralin	Treflan	methyl parathion	Penncap
metolachlor	Dual	parathion	Folidol
cyanazine	Bladex	phorate	Thimet
2,4-D	many	synthetic pyrethroids	many
metribuzin	Sencor	terbufos	Counter
propanil	Stam	toxaphene	Alltox
bentazon	Basagran	chlordane	Aspon

use patterns prevailed. The graphs were updated as new data became available and are presented in Figures 1 and 2 for the seven leading insecticides and in Figures 3 and 4 for the 10 leading herbicides. The length of the bars is the estimated time in days required for 90% of the pesticide to disappear from the soil surface. Since most forms of land disposal involve adding the pesticide directly on the soil, the data in Figures 1, 3, and 4 represent the time required for loss from the surface. For some uses, pesticides are incorporated into the soil and consequently their persistence patterns would be different from those shown. The upper and lower bars represent the normal range within which each pesticide is likely to dissipate by 90%. This range depends on soil and climatic conditions. The persistence data come from a large compilation prepared by Nash (5).

Regulatory actions by the U.S. Environmental Protection Agency in the 1970's removed most of the highly persistent chlorinated hydrocarbon insecticides from the market. Consequently, with the exception of toxaphene (Alltox), most insecticides used currently, methylcarbamates and organophosphates, are biodegradable and disappear rapidly from the soil environment. In fact, there is now serious concern that some readily biodegradable compounds like carbofuran (Furadan) and butylate (Sutan) are disappearing so rapidly that they are failing to control the target pests (3). Soil situations that lead to rapid or enhanced metabolism are termed "problem" soils. The reasons for the formation of "problem" soils are complex, but evidence is accumulating that soil microbial populations responsible for metabolism of these pesticides cause their rapid disappearance.

As a general rule, organic herbicides, when used at normal application rates, do not persist in soils. With the exception of metribuzin (Sencor) and atrazine (AAtrex), most of these herbicides disappear within the growing season. Some herbicides, such as butylate (Sutan) and trifluralin (Treflan), disappear so rapidly from soil surfaces that they must be incorporated into the soil. Soil incorporation generally increases the persistence of herbicides because it reduces the effects of volatilization and photodecomposition.

Land disposal can lead to problems when the natural degradative processes are overwhelmed by massive applications of pesticides. Generally, persistence of most pesticides increases as concentrations in soils increase. For example, the persistence of 2,4-D is between 40 and 75 days when applied at the rate of 1-2 lb per acre. This application rate results in concentrations of about 0.5-1 part per million (ppm) in the surface 6 inches (15.2 cm) of soil. At very high concentration of 2,4-D in soil, i.e. 500 ppm or higher, very little degradation occurred (7). In an EPA-sponsored study (1), it was found that the lag time, or the time required for degradation to begin, was longer for high concentrations (>50 ppm) of 2,4-D and methyl parathion than for lower concentrations. Variables that influenced the rate of degradation of 2,4-D in these studies included formulation, nutrients, soil type, soil pH, temperature, soil water content, organic matter, and microbial ecology. Nevertheless, as concentration of 2,4-D was increased (from 50, 500, 5,000, and 20,000 ppm) the time for degradation also increased. The same trends were observed for methyl parathion (Penncap). At concentrations of 10,100 ppm, very little technical grade or formulated methyl parathion was degraded in two soils after 52 days.

MOVEMENT

The relative downward mobility into soils of the leading herbicides and insecticides are found in Figures 5 and 6. Rather than using actual depth measurements, the pesticides are ranked on the basis of 1 to 10 based on leaching measurements determined by Helling (2) primarily from thin-layer chromatograms. The 10 herbicides are generally more mobile than the 10 insecticides, with the possible exception of carbofuran (Furadan). Based on their mobilities, land disposal without some form of containment could pose a threat for groundwater contamination. It must be stressed that the mobility rankings are simply a relative guideline to leachability. Many soil and climatic conditions may affect the actual mobility. In reality, the degradative processes shown in Figures 1 through 5 are also operating on the pesticides. Therefore, depending on the rate of breakdown, the amount reaching the water table may be small or none.

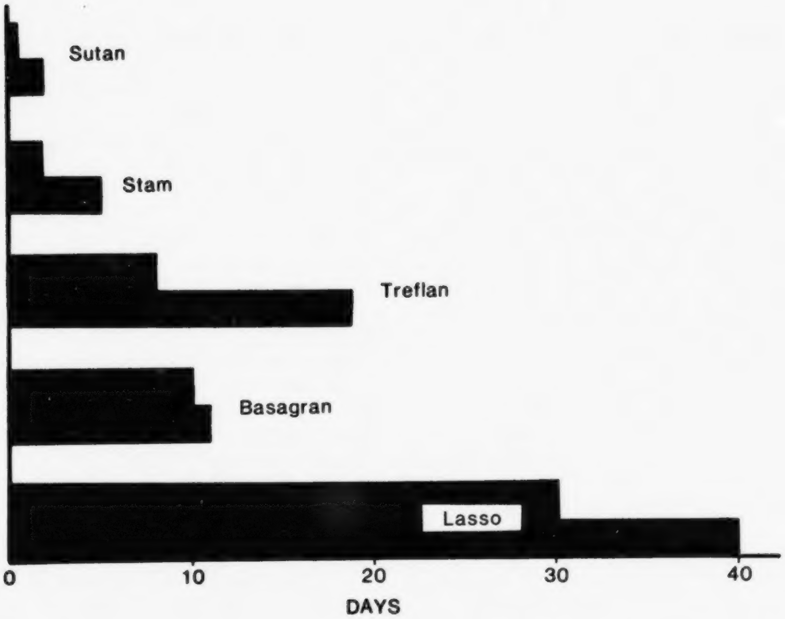

Figure 1. Time in days required for 90% dissipation of the herbicides Sutan, Stam, Treflan, Basagran and Lasso from the soil surface.
(See Table 1 for common names)

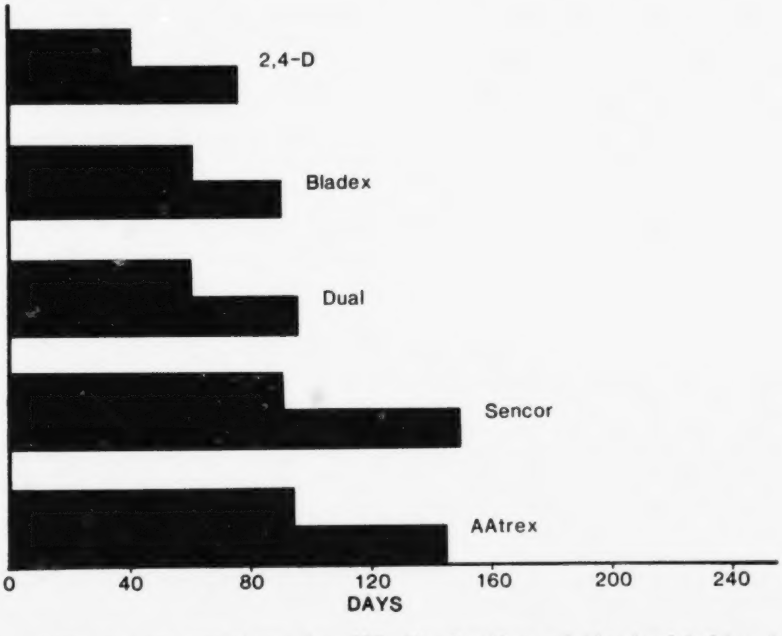

Figure 2. Time in days required for 90% dissipation of the herbicides 1,4-D, Bladex, Dual, Sencor and AAtrex from the soil surface.
(See Table 1 for common names)

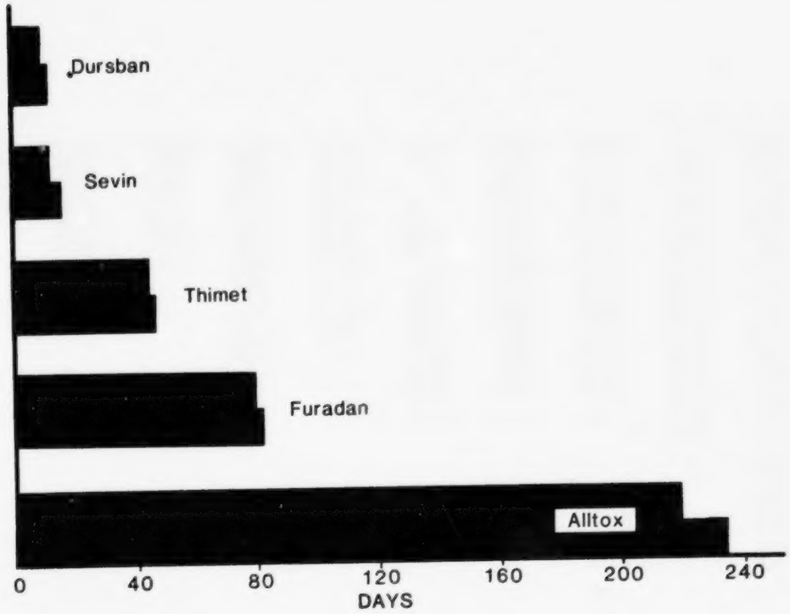

Figure 3. Time in days required for 90% dissipation of the insecticides Dursban, Sevin, Thimet, Furadan and Alltox from the soil surface. (See Table 1 for common names)

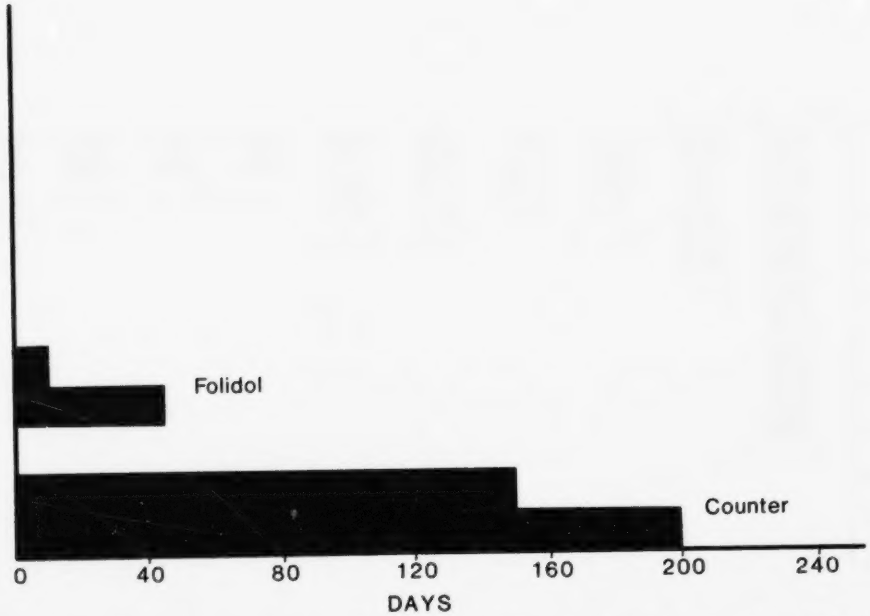

Figure 4. Time in days required for 90% dissipation of the insecticides Folidol and Counter incorporated in soil. (See Table 1 for common names)

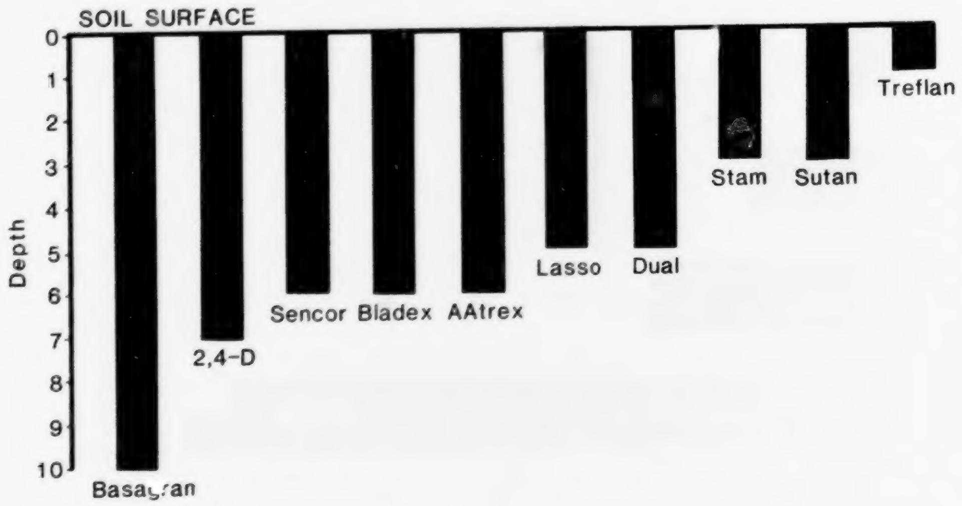

Figure 5. Relative mobility of ten widely used herbicides based on a scale of 1-10.

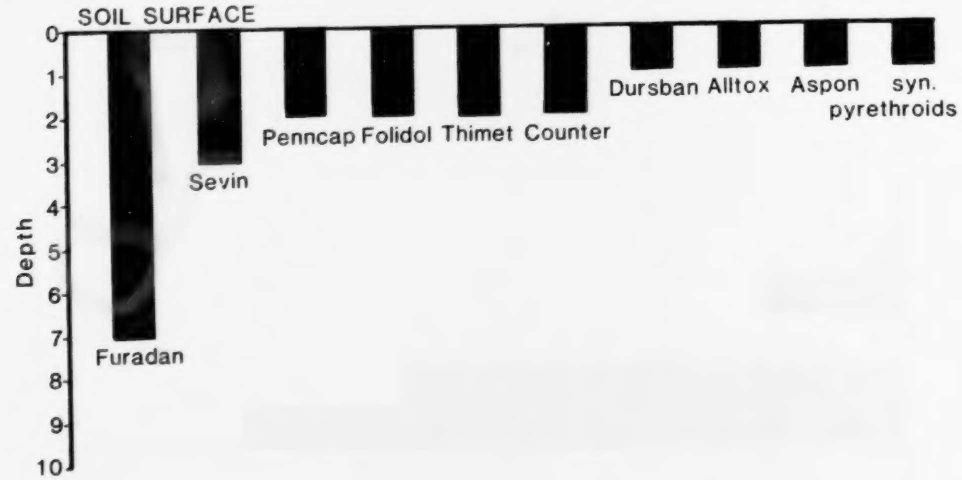

Figure 6. Relative mobility of ten widely used insecticides based on a scale of 1-10.

Problems associated with mobility arise when massive amounts of a pesticide are deposited in a small area, thereby overwhelming the soil's natural ability to degrade or bind the pesticide. The experiments of Davidson et al. (1) show that 2,4-D mobility increases as the concentration in soils increases, and movement with water is virtually nonretarded at 5000 ppm. Due to the greater mobility at higher concentrations, even relatively labile pesticides may move in substantial quantities away from their original disposal site. The property of mobility or movement is a very important factor in designing a waste treatment facility, and particularly any set of conditions that increases mobility must be avoided. Any pretreatment step designed to reduce the concentration, and thus indirectly to reduce persistence and mobility, should be an important feature in any disposal option.

ECONOMICS

From the pesticide user's standpoint, the cost of disposing of a pesticide becomes a major consideration. Each of the options examined in subsequent papers will consider the cost factor. From a practical standpoint, cost is also an important "property" of a pesticide. The purchase price of pesticides, like most other items in our economy, has increased over the last several years.

The sales price, at the manufacturer's level, for herbicides, insecticides fungicides, and all pesticides combined is shown in Table 2. The retail price to the user is not as readily available, but roughly equals twice the manufacturer's price. One survey of aerial applicators (8) showed that roughly 10,000 gallons (37,800L) of wastewater containing 45 lb (20 kg) pesticides are generated each year per plane. Based on the retailer's price of $7.70/lb, this translates to a loss of about $350/year. Any operation that disposes of amounts greater than 45 lb of pesticides per year should re-examine projected use levels to reduce this loss. At the retail price level, this loss can amount to a substantial sum of money.

A second cost "property" that must be considered in any disposal option is the cleanup cost associated with any sites where problems arise. This cost can be substantial. One EPA estimate (6) puts the average cleanup costs at abandoned sites at several million dollars. The cost breakdown is about $800,000 to study the site, $440,000 to design the cleanup, and $7,200,000 for actual cleanup. With the recent passage of the RCRA amendments hazardous waste management requirements are becoming more stringent. This is expected to increase the average cost of remedial actions. To date, 786 sites are listed or proposed for cleanup of about 20,000 sites identified.

There are secondary costs associated with a cleanup operation that may involve legal fees, containment, and site loss for future disposal options; these, too, can be substantial expenses. By comparison to a cleanup operation, the costs associated with effective and safe disposal methods may be nominal.

TABLE 2. INTERNATIONAL TRADE COMMISSION, SYNTHETIC ORGANIC CHEMICALS: U.S. PRODUCTION AND SALES--1982

	Sales of pesticides--Manufacturer's level ($/lb)				
Type	1978	1979	1980	1881	1982
Herbicides	2.78	3.08	3.33	4.02	4.32
Insecticides	2.04	2.32	2.50	3.27	3.38
Fungicides	1.46	1.77	1.98	2.52	2.73
All Pesticides	2.34	2.65	2.90	3.60	3.86

REFERENCES

1. Davidson, J.M., P.S.C. Rao, L.T. Ou, W.B. Wheeler, and D.F. Rothwell, 1980. Adsorption, movement, and biological degradation of large concentrations of selected pesticides in soils. EPA-600/2-80-124. Municipal Environmental Research Laboratory, U.S. Environmental Protection Agency, Cincinnati, Ohio.

2. Helling, Charles S., 1971. Pesticide mobility in soils I. Parameters of soil thin-layer chromatography. Proceedings of the Soil Science Society of America, pp732-737.

3. Kaufman, D.D. and D.F. Edwards, 1983. Pesticide/microbe interaction effects on persistence of pesticides in soil. In J. Miyamoto et al., eds., IUPAC Pesticide Chemistry: Human Welfare and the Environment. Pergamon Press, New York, pp177-182.

4. Kearney, P.C., R.G. Nash, and A.R. Isensee, 1969. Persistence of pesticide residues in soils. In M.W. Miller and G.C. Berg, eds., Chemical Fallout: Current Research on Persistent Pesticides. Charles C. Thomas, Springfield, Illinois, pp54-67.

5. Nash, R.G. Methods for estimating pesticide dissipation from soils. In D.G. DeCoursey, ed., Small Watershed Model, Vol. 3. Unpub.

6. Office of Emergency and Remedial Response, U.S. Environmental Protection Agency, 1985.

7. Ou, L.T., J.M. Davidson, and D.F. Rothwell, 1978. Response of soil microflora to high 2,4-D concentrations on degradation and carbon dioxide evolution in soils. Journal of Environmental Quality, 7, pp241-246.

8. Seiber, J.N., 1981. Disposal of Pesticide Wastewater--Review, Evaluation and Recommendations. U.S. Environmental Protection Agency, DER, ORD Draft report.

PHYSICAL TREATMENT OPTIONS
(Removal of Chemicals from Wastewater by Adsorption, Filtration and/or Coagulation)

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ABSTRACT

A two stage treatment system has been developed to remove pesticides from contaminated wastewater. The first step is primary flocculation and sedimentation. The pesticides in the supernatant can then be adsorbed to activated carbon. The system has been installed by several commercial pesticide applicators. The major problems that users have observed are related to: proper flocculation of the wastewater; selection of a small enough pump to pump the supernatant through the carbon columns; sealing the carbon columns to avoid leaks when under pressure; and disposal of the accumulated sludge and spent activated carbon. All of these problems are correctable with proper supervision. It would be extremely helpful if a commercial company would design and develop the physical equipment and sell the systems to pesticide applicators.

INTRODUCTION

During the past six years a two stage physical treatment system has been developed to remove pesticides from contaminated wastewater. The complete system is the result of four studies. The project was initiated under a USEPA Grant No. R 805 466010. This study (Whittaker, et al. 1982) was conducted to determine the extent of the problem of pesticide contaminated wastewater and evaluate alternative treatment means that might be acceptable to pesticide applicators. As an outgrowth of this project, K. F. Whittaker(1980) evaluated the effectiveness of activated carbon for removal of dissolved pesticides from water. T. J. Ruggieri(1981) then investigated the use of the two stage treatment system to remove 5 RPAR or near RPAR herbicides from a mixed solution of herbicides in water. This study was supported by the North Central Regional Pesticide Impact Assessment Program. The final study performed by K. L. Farrell(1984) investigated the feasibility of encapsulating the two wastes, sludge and spent activated carbon, in a portland cement matrix. This study was also supported by the Pesticide Impact Assessment Program. This paper summarizes the results of these four studies and projects the cost for installing and operating the treatment system.

PURPOSE

In the late 1970's several aerial pesticide applicators in Indiana were in disputes with local airport authorities regarding the handling of pesticide contaminated wastewater. As a result the Indiana Aeronautics Commission requested assistance from Purdue University to develop a system that would prevent ground water pollution or soil contamination around the areas that aerial applicators were using for loading and washing application equipment. A study was initiated to develop a method for collecting and treating the contaminated wastewater. The system was to be simple to operate and capable of producing an effluent that was free of detectable levels of pesticides. The system had to be flexible enough to handle the wide variety of agricultural chemicals currently in use and be equally applicable to ground applicators as well as aerial applicators. The final constraint was that the system must be economically acceptable.

APPROACH

The first step in the development was to characterize the wastewater that had to be treated. Samples were collected from several pesticide applicators during the course of the various research projects and the results were so dependent on the chemicals being applied and the techniques that were used to clean the application equipment that it is difficult to present any meaningful results except that any system that is developed to treat the pesticide contaminated wastewater must be capable of handling a wide variety of concentrations.

The variability in concentration and quantities of wastewater to be treated required that a system be developed that would not be sensitive to these factors. Since evaporation ponds and soil-gravel degradation pits were under investigation at other sites, a physical separation system was investigated. Particle size filtering systems were tested and were found to be either ineffective or of inadequate capacity to be useful in treating the wastewater.

Flocculation was then tested and found to be very effective. Alum, hydroxide coagulation and ferric chloride were evaluated as flocculents. Many other flocculent aids are available and should be considered by any applicator that installs this system. Alum was found to be effective on the wastewater samples that we studied. An anionic polymer (Watcon 1245) was added to enhance settling. Alum concentrations of from 200 to 500 mg/L and polymer concentration of .4mL/L were used throughout the study. Jar tests were performed prior to treatment to select the alum concentration for use.

After the wastewater was flocculated and allowed to settle, the supernatant was pumped through activated carbon columns. Filtrasorb 300 (Calgon Corporation) was used for carbon column with a surface loading rate of 1.5 gallons per minute per square foot of surface area and a 15 minute residence time. The initial carbon columns were made out of water softener columns. The resin was removed from these columns and they were filled with activated carbon.

The system was used in the agricultural engineering department's agricultural waste management lab on the Purdue University campus for one year. Samples were hauled to the lab in a 250 gallon tank mounted in the back of a pickup truck. The wastewater was pumped from the tank into four 100 gallon flocculation tanks. A variable speed mixer was used to mix the flocculent and polymer with the wastewater. The treated wastewater was analyzed for pesticide concentration. In addition to the field samples that were treated, synthetic wastewater solutions were prepared containing malathion, carbaryl and metribuzin.

The system was then mounted in an 8 x 10 trailer and pulled to an applicator's loading pad at Monon, Indiana for field test. The mobile system consisted of two 100 gallon flocculation tanks and two carbon columns. The system would treat 1 gallon per minute. A smaller system was constructed using four 4-inch diameter by 4-foot long carbon columns constructed of PVC pipe. The smaller unit would handle 0.2 gallons per minute.

Following the initial feasibility study, Whittaker(1980) investigated the adsorption of 30 classes of pesticides on activated carbon in isotherm and column studies.

Ruggieri(1981) then investigated the feasibility of using the entire system, flocculation and activated carbon columns, for removal of a mixture of alachlor, dinoseb, trifluralin, paraquat and 2,4-D from wastewater.

During the conduct of the various projects about 5000 gallons of wastewater were treated. As a result about 50 gallons of sludge had accumulated. This sludge was used in a study by Farrell(1984) on the feasibility of encapsulating the sludge with portland cement.

The four studies combine to form a feasibility analysis of a complete system for handling the pesticide contaminated wastewater that is produced by agricultural

TABLE 1. SUMMARY OF ADSORPTION ISOTHERM STUDIES(WHITTAKER, 1980)

Compound Name	Trade Name	Predominant Chemical Class	Molecular Weight	Water Solubility (mg/L @ 20 C)	Carbon Capacity (mg/gm)[1]
Propham	ChemHoe	Amide	179	250	289
Propanil	Stam	Amide	218	0.05%	191
Linuron	Lorox	Urea	249	75	222
Propachlor	Ramrod	Amide	212	580	251
Fluometuron	Cotoran Lanex	Urea	232	90	208
Cycloate	Ro-neet	Amide	215	85	170
Metolachlor	Dual	Amide	284	530	172
Metribuzin	Sencor	Heterocyclic Amine	214	1220	192
Prometone	Pramitol	Heterocyclic Amine	225	750	165
Ametryne	Evik 80W	Heterocyclic Amine	227	185	151
Cynazine	Bladex	Heterocyclic Amine	241	171	156
Diazinon	Basudin	Organophosphate	304	46	214
Fensulfothion	Dasanit	Organophosphate	308	1600	218
Methylparathion	(many)	Organophosphate	183	83	218
Carbaryl	Sevin	Carbamate	187	99	156
Carbofuran	Furadan	Carbamate	229	700	245
Dinoseb	Premerge	Phenolic	240	52	124
2,4-D	(many)	Carboxylic Acid	221	900	73
Naptalam	Alanap	Amide	291	230000	99
Diphenamid	Enide	Amide	239	260	131
Monocrotophos	Azodrin	Organophosphate	223	miscible	153
Phorate	Thimate	Organophosphate	260	85	159
Oxycarboxin	Plantvax	Amide	260	1000	155
Methomyl	Lannate	Carbamate	147	58000	167
CDAA	Pandox	Amide	174	2 %	184
Bentazon	Basagran	Heterocylic Amide	240	500	45
Malathion	Cythion	Organophosphate	330	145	118
Diquat	Ortho-Diquat	Quaternary Nitrogen		very soluble	-
Methamidophos	Monitor	Organophosphate		miscible	-
Dalapon	DowPon	Carboxylic Acid		very soluble	-

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[1] Monolayer carbon capacity according the Langmuir theory.

chemical applicators. The complete system would require a collection system for collecting and storing the contaminated wastewater, the treatment system consisting of at least one flocculation tank and three activated carbon columns, and a small cement mixer for mixing the portland cement, activated the carbon and sludge to form the encapsulated final product.

PROBLEMS ENCOUNTERED

Flocculation of the wastewater is essential to the success of this treatment system. Numerous problems have arisen when the system was used in other parts of the country where alum would not form a floc. Since numerous flocculent aids are available and this technology is used in many municipal and industrial water and wastewater treatment plants one should be able to find an effective substitute for alum. It is recommended that the nearest water or wastewater treatment plant be contacted to obtain effective flocculent aids for your locale.

The carbon columns must be used periodically to prevent bacterial contamination. As a general rule, thumb water should be pumped through the columns at least once a week. If the system is going to be idle for more than a week the columns should be drained. Bacteria will form a slim layer over the carbon, preventing the pesticide molecules from being adsorbed on to the carbon. If the effluent from the carbon columns has an odor it will be necessary to replace the carbon in the columns.

RESULTS

The initial study produced two consistent results. First the wastewater could not be easily characterized because it was highly variable in both concentration of pesticide and quantity of wastewater. As a result a very broad based treatment system had to be employed. Flocculation was chosen for initial treatment and found to be very effective in reducing the concentration of the pesticide to its water solubility.

After treating numerous field produced samples, it was found that the system could reduce the concentration of pesticides to below the detection limits of the Indiana State Chemist Office's pesticide residue lab. Since it was difficult to obtain an accurate estimate of the pesticide concentrations and volume of wastewater, it was impossible to determine the capacity of the carbon columns used for the initial treatment system. The next two studies were conducted to determine the capacity of the activated carbon to remove a variety of pesticides.

Table 1 presents the isotherm data collected by Whittaker(1980) to determine the capacity of carbon for 30 classes of pesticides. Generally between 100 and 300 mg of pesticides can be adsorbed on to a gram of carbon. Three compounds, diquat, methamidophos and dalapon are not readily adsorbed to activated carbon and the Langmuir theory cannot be used to compute a capacity. Generally less than 10 mg of these three pesticides will be adsorbed on to one gram of carbon. Diquat can be easily removed by adding bentonite clay during the flocculation step. No wastewater that was made up of predominantly methamidophos and dalapon has been treated with the system.

TABLE 2. CARBON COLUMN CAPACITY
(Ruggeiri, 1981)

	Carbon Capacity	
Herbicide	Initial Breakthrough (mg/gm)	Maximum Capacity (mg/gm)
Dinoseb	125	250
Alachlor	50	-
2,4-D	10	30

[1] No Alachlor was in the effluent.

Table 2 presents the adsorption capacity of carbon to remove dinoseb, alachlor and 2,4-D.(Ruggieri, 1981) The carbon becomes saturated with 2,4-D first as would be predicted by the results of Whittaker's study. Trifluralin and paraquat were removed during flocculation. This study showed that the carbon columns would become saturated with the most soluble and least adsorbable pesticide compound first. Carbon requirements would have to be based on the most difficult pesticide to adsorb.

TABLE 3. ECAPSULATION OF HERBICIDES

Cement: Sludge: Activated Carbon Ratio	Herbicide		
	Trifluralin (%)[1]	Dinoseb (%)	Alachlor (%)
3:2:0.10	99.7	2.5	0.0
3:2:0.15	99.9	69.4	78.6
3:2:0.20	99.9	69.1	66.9
3:2:0.40	100.	100.	99.8
3:2:0.80	100.	100.	99.9

[1] Percent of herbicide retained in the encapsulated samples that were crushed and subjected to the EPA Extraction Procedure.

Table 3 presents the results of the concrete encapsulation study conducted by Farrell(1984). Concrete cylinders were constructed by mixing the sludge from the flocculation procedure with portland cement and adding varying ratio of powdered activated carbon. The concrete was placed in an 8 oz. paper cup and allowed to set for 28 days. The EPA Extraction Procedure was used to determine the percent of pesticide encapsulation. The Indiana State Chemist Office analyzed the samples for dinoseb, trifluralin, and alachlor. Only 0.1% of the alachlor leached out of crushed samples of the concrete when a mixture of 3 parts cement, 2 parts sludge and 0.8 parts activated carbon was used. All of the other two herbicides were retained in the concrete encapsulate. This technique shows promise of providing a safe and simple method of handling the sludge and spent carbon.

In summary, primary flocculation and sedimentation followed by activated carbon adsorption appears to be a feasible means of handling pesticide contaminated wastewater. The system has been used on a variety of pesticide contaminated wastewaters. Proper flocculation is very important and it is sometimes necessary to receive assistance from a distributor of flocculent aids, such as Nalco Chemical Co. In test in Indiana, alum dosages of 300-500 mg/L were effective when used with an anionic polymer. The sedimentation step can be accomplished in a 55 gallon drum. A variable speed mixer is needed to assure proper flocculation and sedimentation. A flat blade paddle mixer, about 4 x 8 inches attached to the end of a 3 foot rod can be mounted on a variable speed electric motor and used as the mixer. The mixer should have at least 2 speeds. A 100-300 rpm mixing speed is necessary for mixing the chemicals for 15 minutes initially, followed by a 30 minute slow mix at 5-20 rpm to build the floc. Since the flocculation step is critical it is important to use the most effective polymer available. Persons interested in installing such a treatment system should seek advice from a local water or wastewater treatment plant or a supplier of flocculent aids to be sure that the initial flocculation step removes as much of the pesticides and carriers as possible. If the wastewater contains paraquat, bentonite clay should be added during flocculation.

The translucent supernatant that remains after the flocculated wastewater is allowed to settle will contain the dissolved pesticides. This liquid should be pumped through a series of activated carbon columns, usually 4. PVC or ABS pipe can be used to construct these columns. Four foot lengths of four or six inch diameter pipe will hold enough activated carbon to treat 2000 to 5000 gallons of most wastewater. The flow rate should be less than 1 gpm/ft^2 and the contact time should be at least 15 minutes. A pump that will deliver 0.1 to 0.2 gpm at 10 psi pressure should be used with the 4 or 6 inch diameter columns, respectively. Under these conditions approximately .25 grams of pesticide can be adsorbed on each gram of carbon.

Based on the results to date, a 55 gallon drum of flocculent will treat over 1000 gallons of wastewater. Four 6-inch diameter, 4-foot long columns will hold about 200 lbs. of carbon and will be capable of handling at least 5000 gallons of wastewater. The carbon costs about $1.00 per pound. Total cost of chemicals for treatment of the wastewater is about $.20 per gallon. A typical agricultural chemical applicator would produce 5000 gallons of wastewater per year. The cost of the mixer and tank would be less than $1000. The major cost would be the construction of a collection system to collect the wash water used to clean the application equipment.

The system produces two hazardous solid wastes. The sludge that accumulates from the flocculation and sedimentation and the spent activated carbon. The sludge can be reused in the sedimentation step until the volume of sludge limits the quality of supernatant. The total volume of pesticide contaminated waste is substantially reduced. Approximately 100 gallons of sludge and 200 pounds of spent activated carbon will be produced when 5000 gallons of wastewater is treated.

Using the simple encapsulation process that has been described in which the sludge is mixed with powdered activated carbon and portland cement, it would be possible to produce a concrete block that will meet the EPA Extraction Procedure test and would not be considered a hazardous waste. The 100 gallons of sludge and 200 pounds of spent activated carbon produced during the treatment of 5000 gallons of wastewater can be encapsulated in about 2 cubic yards of concrete.

The treatment system that has been developed can be used to remove the pesticides from the wastewater that is produced during cleanup of application equipment. The equipment is simple to operate and provides applicators with a realistic alternative for managing their contaminated wastewater.

ACKNOWLEDGEMENTS

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Three graduate students, T.J. Ruggieri, K.F. Whittaker, and K.L. Farrell conducted research and wrote theses on various segments of the entire system. Their work combined to provide the technical basis for the recommendations presented in this paper.

REFERENCES

1. Farrell, K. L. and J. C. Nye, 1984. Concrete encapsulation of pesticide contaminated sludge. ASAE paper no. 84-4574. American Society of Agricultural Engineers, St. Joseph, MI, p10.
2. Ruggieri, T. J. 1981. Determination of the ability of a flocculation/sedimentation/activated carbon treatment plant to remove herbicides from application equipment washwater and examination of the feasibility of bioassays for determination of activated carbon exhaustion. MSE thesis. Purdue University, West Lafayette, IN, p141.
3. Whittaker, K. F., 1980. Adsorption of selected pesticides by activated carbon using isotherm and continuous flow column system, Ph. D. thesis, Purdue University, West Lafayette, IN, p342.
4. Whittaker, K. F., J. C. Nye, R. F. Wukasch, R. G. Squires, A. C. York and H. A. Kazimier, 1982. Collection and treatment of wastewater generated by pesticide applicators, PB 82-255 365, Oil and Hazardous Materials Spills Branch, MERL-Cincinnati, USEPA, Edison, NJ, p98.

A Practical System to Treat Pesticide-Laden Wastewater

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ABSTRACT

A treatment system based on recirculation of pesticide-contaminated wastewater through a bed of granular activated carbon is described. Testing demonstrated that a mixture of seven pesticides could be removed from 400 gallons of water with 45 lb of granular carbon. The most challenging test purified 400 gallons of water containing of 100 PPM of each pesticide. The process has a mathematical basis and thereby predictable. The system is inexpensive and simple to operate; the spent carbon has a very low leach rate.

INTRODUCTION:

Businesses supporting agricultural production such as small farmers and aerial pesticide applicators have need of a pesticide waste disposal process that is simple to use, effective for a wide variety of pesticides and herbicides and inexpensive. Such a system was developed for use by the US Army and installed at Ft. Eustis, VA in 1981. At that time it was clear that this system had a direct application to any generator of small volumes of mixed pesticide wastes if the batch could be confined to a volume below 2000 gallons.

The pest control facility at Ft. Eustis has a unique waste drainage system whereby all pesticide wastewater is collected from mixing operations, storage area spills, container rinsing and washdown of dispersal equipment. This wastewater drains into a sump in the floor of a waste treatment room adjunct to the main building. When a sufficient volume is collected (500 gallons), it is treated to remove pesticides by recirculation through activated carbon. When treatment is complete (24 hours), the water is transferred to a second tank and later used as a diluent to make fresh pesticide formulations for spray applications.

PURPOSE:

This article will summarize the development and testing of an activated carbon treatment system assembled to remove pesticides from water. Detailed information on system assembly, experimental methods and test data is available from other published material (1, 2, 5) and will not be given here.

APPROACH:

During FY 79-80, research was funded jointly by the US Army Training and Doctrine Command and the Environmental Protection Agency to design, build and test a system to treat pesticide-laden wastewater. The system would be based on adsorption of pesticides by activated carbon. The goal was to produce a workable system under $3,000 (in capital equipment) that would be easy to operate and maintain, and need little attention during operation. By August, 1982, this goal was achieved.

The adsorption of organic chemicals from water by activated carbon is a well-known phenomenon. It has broad application. The efficacy and low cost of carbon adsorption are attested by its common use in water treatment plants for removal of color and odor from raw water.

DESCRIPTION:

The treatment system is built around the CARBOLATOR 35 water purification unit (6). Figure 1 shows the drawing of the treatment concept.

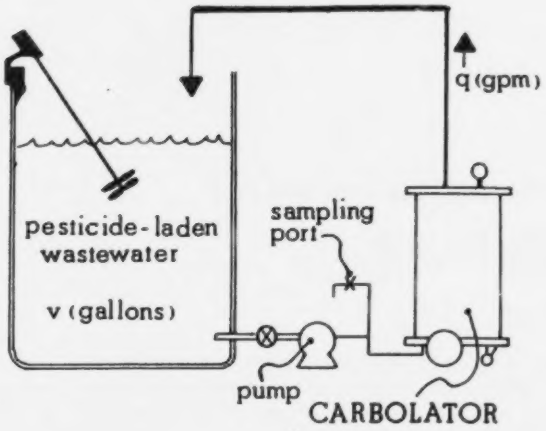

FIGURE 1. Schematic Drawing of Test Assembly Used at Fort Detrick, April, 1981.

The CARBOLATOR 35 is light-weight and portable, consisting of an 18-gallon reinforced epoxy tank with an O-ring seal cover. The granular carbon is held in two polypropylene bags within the tank. Wastewater from the holding tank is then pumped continuously into the bottom of the CARBOLATOR and upward through the carbon bed. The effluent water is returned to the waste-holding tank. Upward flow reduces channeling and compaction of the carbon bed, problems common to a down-flow configuration. Moreover, the operation of this recirculation system can be described mathematically by:

$$C_t/C_o = \epsilon^{-kqt/v}$$

where:

C_t = the concentration of pesticide at any time (minutes) after treatment begins.

C_o = the concentration of pesticides in the wastewater before treatment begins.

q = the flow rate (gallons per minute) passing through the carbon bed.

v = the volume of water (gallons) being processed.

t = the time (minutes) in operation.

k = the efficiency constant, or the fraction of pesticide removed when a unit volume passes through the carbon bed.

The mathematical basis of this configuration gives the process predictability. For example, if the concentration of pesticide is given the value of 1.0 and the volume of waste is 500 gallons, it is possible to calculate how long the system must run in order to reach a desired level. Let the desired pesticide level be 0.001 and the flow rate through the system be 10 gallons per minute. If we assume a removal efficiency of 0.5 (k = 0.5), then:

$$\ln (C_t/C_o) = -kqt/v$$

$$\ln 0.001/1 = -0.5(10)(t)/500$$

$$-6.907 = -0.01(t)$$

$$t = 691 \text{ minutes} = 11.5 \text{ hours}$$

Of course, dropping from a level of 1 to 0.001 is a 99.9% removal of pesticides in 11.5 hours.

RESULTS:

The first test of the system was carried out at the US Army Medical Bioengineering R&D Lab at Ft. Detrick, MD. Of three tests performed, the most challenging to the system involved treatment of 400 gallons of water containing a mixture of seven different pesticide formulations. The concentration of each pesticide was 100 PPM. During the treatment, the tank was stirred while wastewater was pumped at 6.4 gpm through 45 lb of Calgon F-300 activated carbon within the CARBOLATOR. Stirring was needed to insure homogeneity of the tank contents, for the validity of the equation requires homogeneity. The decrease of pesticides in the water was monitored by gas chromatographic analysis. Details of chemical analysis and complete concentration vs. time data for all tests are described elsewhere (2). Table 1 presents an abbreviated array of data for the most concentrated wastewater.

Table 1. Decrease in Pesticides (PPM) with time - Ft. Detrick, MD, Feb 1981

Pesticide	0hr	1hr	2hr	3hr	6hr	10hr	20hr
Baygon	100	65	42	30	15	5	0
Dimethoate	100	62	40	31	16	3	0
Diazinon	100	54	46	46	24	7	1
Ronnel	100	47	55	44	38	15	2
Malathion	100	54	44	38	19	5	1

(continued - next page)

Table 1 - continued:

Pesticides	0hr	1hr	2hr	3hr	6hr	10hr	20hr
Dursban	100	59	52	52	32	14	3
2,4-D ester	100	69	54	52	33	20	6

As predicted by the equation, all pesticides decreased with time exponentially. Also, when the measured rate of decline is compared with the theoretical decline (where k = 1.0), all pesticides deviated from the ideal rate of removal. All showed fractional values of k. At the 100 PPM level Baygon (Propoxur) showed the highest k value at 0.32 and 2,4-D ester the lowest with k = 0.16. With a more dilute waste (20 PPM in each pesticide) there was greater efficiency in removal. Again Baygon showed the highest efficiency (k = 0.82) and 2,4-D ester the lowest (k = 0.56). In addition to the seven pesticides listed in Table 1, four others were briefly examined in bench-scale (1 gallon) adsorption testes (2,5). All were removed from water by Calgon F-300. These were: 2,4-D amine salt (2), parathion (3), carbaryl (3) and chlordane (2). The former was removed most efficiently (k = 1.0 at 100 ppM).

The disposal of spent carbon was also considered during these first tests. Landfill disposal of the carbon can be considered if the carbon can be shown not to be a hazardous waste as defined by the EPA. A test has been published by EPA (4) to measure the degree to which hazardous pollutants leach from a solid waste. To test the leaching characteristics, the carbon having the highest level of adsorbed pesticides (that used in the experiment in Table 1) was subjected to the leach test. Details of this leach test are found in the Federal Register (4) and the description of the procedure followed and chemical analysis of leachate have been published (2). Table 2 shows that after 24 hours contact with water, a carbon holding 5.4% of its weight in pesticides yields little of the adsorbed pollutant.

Table 2. Analysis of aqueous leachate after exposure of water (pH 5) to Calgon F-300 holding 5.4% of pesticides - concentration of pesticides given as parts per billion (ppB).

Pesticide	concentration in leachate (ppB)
Dimethoate	4.0
Baygon	8.0
Ronnel	0.2
Malathion	0.3
Diazinon	0.1
Dursban	0.2
2,4-D ester	10.0

Following three sucessful tests with a prepared waste under ideal conditions, the treatment system was taken to Ft. Eustis, VA for testing with wastewater from actual operations. This waste was found to have a large amount of suspended solids. To trap the grit, a ten micron cartridge filter was added to the treatment line (placed between the pump and the CARBOLATOR). Figure 2 shows a schematic drawing of the final assembly installed at Ft. Eustis. Tables 3 and 4 present the removal of pesticides from Ft. Eustis wastewater as a function of operation time. The rates of removal found with the Ft. Eustis waste were similar to those observed in the Ft. Detrick tests.

Table 3. Decrease in pesticide concentration (ppM) with time, Ft. Eustis, VA, July 1981, 600 gallons wastewater at 6.1 gpm through 30 lb Calgon F-300 carbon.

Pesticide	0hr	2hr	3hr	5hr	7hr	24hr
Dimethoate	48	31	23	9	4	0
Malathion	34	18	15	2	0	0
Baygon	2.5	1.4	0.8	0.5	0.2	0
Diazinon	0.5	0.5	0.5	0.6	0	

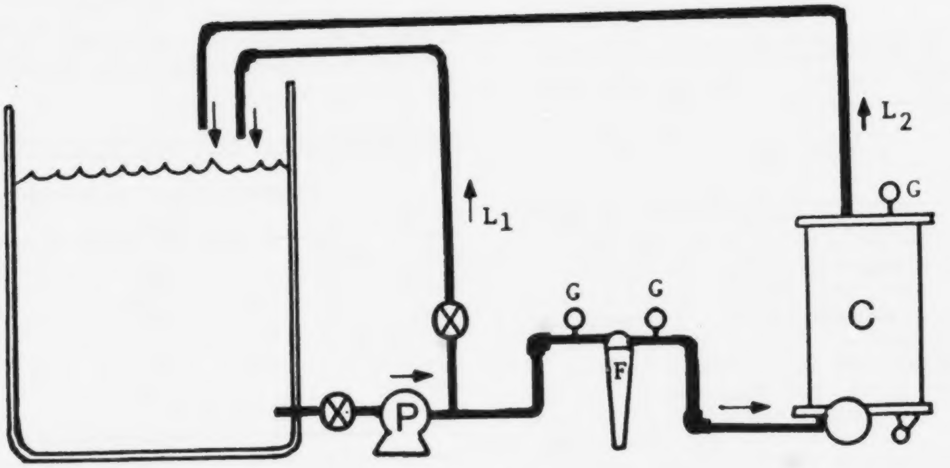

Figure 2. Schematic drawing of system for treating water contaminated with pesticides. A ½ HP pump (P) passes water through a cartridge filter and into bottom of CARBOLATOR (C). Part of the flow is diverted through line L1 to maintain homogeneity of tank contents. Carbon treated effluent passes back into tank through line L2 for recirculation.

Table 4. Decrease in pesticide concentration (ppM) with time, Ft. Eustis, VA, Sept 1981, 410 gallons at 6.0 gpm, 40 lb Calgon F-300.

Pesticide	0hr	1hr	3hr	5hr	10hr	20hr
Malathion	82	7	0	0	0	0
Baygon	41	31	14	6	0.5	0
Dursban	19	15	8	5	2	0.3
Dimethoate	17	13	6	3	0	0
Diazinon	10	7	4	2	0.1	0
2,4 -D	6	5	4	2	0.1	0.1

By the summer of 1982, the final configuration (Figure 2) was set and testing completed. The system was turned over for use by the pest control operators at Ft. Eustis. Since that time the system has remained in use and similar systems have been (or will be) installed at nine other Army pest control facilities (7).

PROBLEMS:

A. Employing k-values

Caution is advised in using k values to predict how long to operate the system in order to achieve a certain degree of pesticide removal. A systematic variation in all operational parameters was not done and the value of k for a different set of parameters would be uncertain. Efficiency of pesticide removal will be influenced by the following factors:

1. Configuration

Channeling can occur in the carbon bed causing poor contact between the water and granular carbon. Careful placement of the bags of carbon in the CARBOLATOR will give good contact, thus giving a higher value of k.

2. Carbon Loading

At a given flow rate, the water will contact more carbon in a larger carbon bed. Since k is actually the fraction of pesticide removed when a unit volume passes through a bed, a larger carbon bed will give a larger value of k.

3. Pesticide Concentration

As stated above, when flow, volume and carbon bed are held constant, efficiency increases with decreasing pesticide concentration in the waste.

4. Carbon Type

In all testing described (1,2,5), only Calgon F-300 activated carbon was employed. It is likely that other carbon types would show varying efficiencies.

B. Effluent Analyses

Although this system removes pesticides from water and is simple to operate, the time needed to atain a specific degree of removal remains uncertain. To insure the absence of pesticides in the effluent, a simple chemical test would be beneficial. During the Ft. Eustis operations, a simple method for analyzing the effluent was devised. This technique was thin-layer chromatography, TLC (2). Briefly, an aliquot of water is extracted with an organic solvent and a portion of the extract placed on a small glass plate coated with silica gel. To each side of the spot is placed a solution containing the pesticides known to be in the waste. The plate is then placed into a jar containing sufficient solvent to immerse several millimeters of the plate below the area of sample application. When the solvent has risen (by capillary action) about 10 cm, the silica gel plate is removed, dried and is sprayed with a reagent that reacts chemically with the pesticides to produce a visible spot. Any spots present in the sample are compared with those in the standard mixture. This gives a qualitative analysis of the effluent water and allows the operator to judge the degree of pesticide removal achieved. Glassware and materials to perform TLC are quite inexpensive and readily available. Although the analysis is best carried out by a chemist, the pest control operators at Ft. Eustis were trained in the use of the TLC technique.

C. Lack of Operational Data

Some operational data is available for the removal of seven pesticides from wastewater. However, variation in the parameters of flow, carbon loading, carbon type, waste volume and waste concentration are very limited. The pesticides studied reflect those in use at Army facilities and not those common to agriculture. Indeed, further work is needed to assess this method of water treatment for waters contaminated with pesticides and herbicides that are in widespread use by farmers and aerial applicators.

REFERENCES:

1. Dennis, W.H. and E.A. Kobylinski, 1983. Pesticide-laden Wastewater Treatment for Small Waste Generators, Environ. Sci. & Health, B18, pp 317-331.

2. Dennis, W.H., A.B. Rosencrance, T.M. Trybus, C.W.R. Wade and E.R. Kobylinski, Treatment of Pesticide-laden Wastewaters From Army Pest Control Facilities by Activated Carbon Filtration Using the CARBOLATOR Treatment System, US Army Medical Bioengineering R&D Laboratory, Technical Report 3203, Aug 1983, AD A138399.

3. Dennis, W.H., Laboratory Notebooks, unpublished data, 1979-1982.

4. Federal Register, Rules and Regulations, Vol. 45 No. 98, May 19, 1980.

5. Kobylinski, E.A., W.H. Dennis and A.B. Rosencrance, 1984, "Treatment of Pesticide-laden Wastewater by Recirculation Through Activated Carbon", in Treatment and Disposal of Pesticide Wastes, ed. R.F. Krueger and J.N. Seiber, ACS Symposium Series 259, ACS, Washington, D.C.

6. Sethco MFG Corp., Freeport, NY 11520 Bulletin 451.

7. Spencer, B., HQ-TRADOC, Ft. Monroe, VA, Personal communications, Feb 1985.

PESTICIDE WASTEWATER DISPOSAL: BIOLOGICAL METHODS

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The potential of microorganisms to metabolize pesticides is well documented. Indeed, biological treatment has been used industrially to treat pesticide manufacturing wastes. Microbial metabolism of pesticides is an integral part of many disposal systems, particularly those that use soil as a component. A brief review of the types of pesticides degraded by soil microbes, and the metabolic reactions and microbes involved will be presented as background for the discussion of available biological disposal methods. Most of the methods that will be described have a limited use on a large-scale basis and due to their complexity, would not be economically feasible on a small scale. Examples of these effective but costly systems are activated sludge treatment systems and trickling filter systems. Two systems that have utilized a combination of evaporation beds and soil will also be discussed with relation to the contribution of biological pesticide degradation. Other biological systems that are still under experimental development (e.g., enzymatic methods) will also be discussed. In general, biological methods are effective for the detoxification of most types of pesticide waste, but due to regulatory constraints may not have applications for small scale pesticide waste generators. Biological methods may be quite useful in the clean-up of currently existing pesticide waste disposal sites. An example of a situation of this type in California will be presented.

INTRODUCTION:

I would like to address pesticide waste disposal from two perspectives. The first is the need of applicators to find reasonable, inexpensive and environmentally safe methods to deal with current and future dilute pesticide solution (DPS) disposal. The second is the need for applicators and regulatory agencies to find reasonable, inexpensive and environmentally safe methods to clean up sites used for pesticide applicator waste disposal in the past that do not conform to current regulatory specifications.

The focus of this presentation will be on the biological treatment of dilute pesticide solutions which we will define as solutions of pesticides that are below the concentrations usually applied in agriculture. The main source of this type of wastewater would be from rinsing and washing down application equipment as well as disposing of unused solutions. Pesticide container disposal, which will be covered in a presentation later today, is another possible source of DPS.

One point I would like to make is that we consider DPS to be a special category of hazardous waste and that as such, DPS should receive a different regulatory treatment than other hazardous wastes. Most contemporary pesticides are now designed to breakdown naturally in the environment into less toxic materials, and this fact should be taken into account when considering how DPS should be regulated.

BIOLOGICAL DEGRADATION OF PESTICIDES

Dr. Kearney has already presented an overview of pesticide degradation properties, and I would like to expand on it a bit to cover biological pesticide degradation. We will define biological pesticide degradation as the chemical breakdown of pesticides mediated by microorganisms, plants and subcellular systems (such as enzymes) that have originated from living cells. The metabolism of pesticides by soil microorganisms is one of the major routes of .pa pesticide degradation after agricultural pesticide application. Microbial pesticide degradation can take place in two ways, as a result of co-metabolism, or with the pesticide used as a carbon source for the microbes involved. Co-metabolism occurs when the pesticide is metabolized by the organism, but the products of the metabolism are not incorporated into the organism. When a pesticide is used as a carbon source for an organism, it might be considered as a nutrient since the products of metabolism are incorporated into the chemical structure of the organism (proteins, carbohydrates, etc).

The most important reactions that occur in biological degradation include oxidation, reduction, and hydrolysis. The result of these reactions are metabolites that are generally more water soluble than the parent compound, and that are also less toxic. In many cases the metabolites may be further metabolized and the ultimate end products are carbon dioxide, water, and salts. Some of the many factors that influence biological pesticide degradation in soils are soil type, organic matter content, degree of hydration, temperature, types of microbes present, numbers of microbes present, pH, and oxygen level. I also should mention that chemical insult can influence biological activity particularly at high concentrations. In general, microbial metabolism is best in soils that are warm, moist, well oxygenated, and which have lots of organic matter. It is also important to recognize that soils may become acclimated to pesticide use and the microbes induced to metabolize pesticides faster than after the first application. This results in a more rapid removal of the pesticide from the soil.

Biological pesticide degradation is very dependent on the pesticide involved. For example, the organophosphates, carbamates, and pyrethroids are much more readily metabolized by microbes under aerobic conditions than are the organochlorine insecticides. However even DDT and toxaphene are susceptible to microbial metabolism under anaerobic conditions. The chlorinated phenoxy herbicides for example are quite susceptible to biological degradation whereas paraquat is quite resistant to metabolism by microbes.

Some work that has been underway at Davis and which will soon be reported by Schoen and Winterlin has shown that pesticide degradation is greatly influenced by concentration, organic matter, and the amount of moisture in the soil medium, not to mention other factors such as pH, soil type, etc. Many of these factors influence the type of microbial activity which in turn effects the degradation process. One of the more interesting facets of this study was the discovery that there is no one factor that is best for all pesticides or even within a classification of pesticides. The conditions that may be optimum for one pesticide may or may not be for another. Therefore the more degradation processes that can be incorporated into the DPS disposal process, the more effective it will be in degrading mixtures of pesticides. If one can incorporate aerobic and anaerobic conditions, as well as organic matter and other treatments and amendments, it is possible to enhance microbial degradation of pesticide mixtures in DPS. I will now present some systems that have been used in the past or that are presently in operation, and which incorporate biological methods for enhancing the degradation of pesticides and pesticide manufacturing wastes.

INDUSTRIAL PESTICIDE WASTE DISPOSAL

The individuals who were first faced

with the problems of pesticide waste disposal were the manufacturers, and they have developed the technologies to a very sophisticated level. The best documented biological, industrial pesticide disposal techniques are those used for treatment of organophosphate manufacturing wastes. In 1966 Coley and Stutz described the development of an activated sludge treatment system for organophosphate manufacturing waste for Monsanto. An activated sludge system is composed of a concentrated biomass which is supplied with nutrients and oxygen in order to promote the most efficient use of the waste by the microorganisms (Figure 1). Their first experiment was conducted at a city sewage treatment plant under an agreement that specified that if Monsanto could prove that the parathion wastes and domestic wastes could be adequately treated together, the city would accept the parathion waste for treatment. This was the case but when Monsanto expanded its operations, the city treatment plant could not handle the additional load and Monsanto developed its own activated sludge treatment facility. The system developed by Monsanto included some preliminary treatments to neutralize acidity and the addition of chlorine to control odor (Figure 2). After a 7-10 day treatment period which was found to be necessary for complete destruction of parathion and paranitrophenol, the sludge was allowed to settle, and the treated effluent was discharged into the city sewer system. The sludge was then recirculated and remixed with new parathion waste.

The Monsanto system requires intensive management due to the high degree of biotoxicity of the parathion waste. Samples were taken as often as every four hours to monitor the status of the system and adjust the inflow of the waste so as not to shock the activated sludge.

In 1968 Lue-Hing and Brady described a system designed for Chemagro Corporation. This activated sludge system was designed to degrade a mixture of organophosphates such as guthion, meta-systox, coumaphos, and fenthion. The final design utilized a first-stage activated sludge process to absorb some of the shock that this waste had on the microbes, and a second stage activated sludge process for the ultimate degradation (Figure 3). The authors noted the sensitivity of the activated sludge system to heavy loads of waste, and that it took at least 30 days for the system to become acclimated to the waste when the system was first used.

In 1969, Howe mentioned the development of a biological treatment method for trifluralin, but did not disclose any details of the system. Atkins (1972) performed a survey for EPA and reported that a trickling filter and activated sludge process was used successfully for the treatment of 2,4-D waste. The trickling filter is a system composed of a deep bed filled with stones (or other suitable media) 2-4 inches in diameter (Figure 4). Wastewater is dripped over the bed and air flows up through the bed from the bottom. Biological slimes attach themselves to the surface of the rocks and utilize the waste as they trickle over the stones. As the slime layer builds up, it eventually sloughs off (Figure 5). The trickling filter can handle large pulse loads of toxics because the contact time is short. Thus a toxic pulse may kill off the surface layer of the slime, but the lower layers survive to utilize the waste. This makes the trickling filter a good pretreatment device for biologically degradable toxic wastes. Atkins (1972) also discussed the use of aerated lagoons and simple stabilization ponds for treatment of pesticide wastes. These two methods, while somewhat effective, are also quite slow and thus not much utilized by industry.

These two "industrial strength" pesticide waste treatment methods are excellent examples of the efficiency of biological processes for treating certain hazardous wastes. They are environmentally safe hazardous material treatment methods and as such are regulated as treatment facilities. The principle advantage of these systems is their efficiency in almost completely degrading different types of pesticides and that waste can be treated on site, with little left over material for landfill disposal or incineration. There are numerous disadvantages to these systems when viewed through the eyes of a small waste generator. They require considerable monitoring and testing to insure proper operation, they take up a fair amount of space, and they are expensive to build and maintain. In 1979, SCS Engineers prepared a report for EPA on the disposal of DPS that included cost estimates for activated sludge and trickling filter systems. Their estimates are based on 225 days of operation per year and a volume of 450 gallons of waste per day. Their estimates are shown in Figure 6. It is readily apparent that these systems are costly to build and maintain. In addition, there is no information available as to their effectiveness when used to treat complex mixtures of different classes of pesticides.

CONSUMERORIENTED PESTICIDE DISPOSAL SYSTEMS

I will now discuss two different but similar systems currently in use at University field stations, one in Iowa and the other in California. Both of these systems contain soil as one of the components and thus biological pesticide degradation is involved in processing waste in both of these systems. The Iowa State University system is a concrete pit 0.9 meters deep at one end, 1.2 meters deep at the other and is 8.8 m long and 3.7 m wide (Figure 7). It has a movable cover to prevent entry of rainwater and the system has been used for pesticide disposal for over 12 years. The pit is stratified and the top and bottom layers consist of 4 cm diameter gravel, and the middle layer consists of topsoil. A complete description of the system and the studies performed on it was published by Hall et al. in 1981. Pesticide wastes enter by rinsing out tanks directly into the disposal pit. This results in an uneven loading of pesticide wastes into the pit which may be advantageous if the concentration of pesticide in the wastewater is very high.

The pit has been used for the disposal of chlorinated hydrocarbons, organophosphates, carbamates, triazines and others. Hall (1984) reported that this pit has received over 50 kg of 40 different pesticides since it began operation (Figure 8). Hall et al. (1981) reported that there has not been significant accumulation of any pesticide in the pit, that it has not leaked, that microbes flourish in the soil and water, and that it has been highly successful as a disposal facility for DPS. Johnson and Hartman, (1980) have published the results of the microbiological studies carried out on this disposal facility. They reported that there was substantial biological activity in the pit based on the fluctuation of the numbers of bacteria in the pit during the study. They also found that bacterial isolates from the pit would grow on filter-sterilized pit liquid. They concluded that this data is strong indirect evidence that the bacteria are involved in the metabolism of pesticides in the pit, particularly when all other processes of degradation are taken into consideration.

The University of California Experiment Stations have installed evapotranspiration inspired systems at field stations throughout California. These systems are lined beds to which the wastewater is introduced through perforated pipes which lie under gravel on the bottom of the bed (Figure 9). The gravel is covered by from 10 to 20 inches of topsoil. Pesticide wastewaters are collected from equipment washpads, passed through a sedimentation box, and then directed into a distribution box where the liquid is passed into the bed leach lines. At two sites, the liquid is stored in tanks, and then metered into the beds. The ideal situation is to keep the top layer of soil moist but not flooded, and thus promote evaporation. This is not always the case since the beds are sometimes overfilled during peak seasonal use, or the storage tanks often fill and are emptied into the beds faster than evaporation can occur. This may not be detrimental since this process results in both aerobic and anaerobic conditions that are important when a broad spectrum of pesticides are introduced into the system.

These beds have been in operation for 4 to 8 years and in 1981 we undertook a study to determine their effectiveness and environmental safety. Results of these extensive studies have shown that the beds will function well if operated properly. The highest levels of pesticide are found in the top 1 inch of the soil due to mass transport of the pesticides to the surface which is sometimes referred to as the "wicking" effect. Several of the beds have had lime incorporated into the soil in order to provide a basic environment which is conducive to chemical hydrolysis of organophosphates, carbamates, and certain other pesticides.

Schoen in her recent work with one of the California evaporation beds incorporated 2" diameter open ended PVC tubes into the beds. The tubes which were 12" long were inserted into the beds in each of four quadrants in such a manner as to have the tubes in contact with the underlying gravel. The tubes were packed with a silt loam soil which had been amended with acid or base to give a pH of 4, 7.2, and 10 respectively. The tubes were then removed periodically and analyzed for 5 detectable pesticides. Each column of soil removed from the tube was divided into three segments, 0-1", 1-6" and 6-12". Results from this study showed mass transport of the pesticides with time to the soil surface, and although degradation was attributed to hydrolysis in a few cases the primary cause of degradation appeared to be microbial. Even though this particular study was conducted in the cool northern regions of California, microbial degradation was effective in reducing the concentration by approximately 66% in 16 months and 90% or more after 24 months in all three pH adjusted soils.

Both of the systems just described appear to be quite effective and environmentally safe. Current technology (and regulations) make it advisable that lined bed disposal facilities should have a means for detecting whether leaks have developed, and these features could easily be incorporated into these systems. California regulations currently require pesticide disposal beds to have double liners, and a means of detecting leakage of the top liner. Technically, both of these systems are hazardous waste treatment facilities, which makes them subject to considerable regulatory constraints. These constraints may be indeed the biggest disadvantage of these systems because on the whole, they are economical and require little maintenance or chemical sampling. Both of the systems also act as evaporation beds, and research is currently underway at the University of California Davis to find means to enhance the evaporation capacity of the UC disposal beds. Estimates of the costs of these systems, as calculated by SCS Engineers in 1979, and based on 225 days of operation per year and 450 gallons of waste per day are shown in Figure 10.

CURRENT RESEARCH AREAS

Composting:

The effects of composting on pesticide degradation is also being explored as a practical method of disposal or detoxification. In 1981, Seiber et al. reported on the effects of composting cotton gin trash on residue levels of sodium chlorate, methidathion, omite, DEF and paraquat. They found that sodium chlorate levels of greater than 400 ppm could be reduced to undetectable levels in 5 weeks by aerobic composting, and in 8 weeks by anaerobic composting of cotton gin trash. Methidathion levels of 2 ppm were reduced to undetectable levels in 5 weeks by either aerobic or anaerobic composting. Omite levels of about 3 ppm were reduced to undetectable levels in 8 weeks, and to 1.2 ppm in 8 weeks by aerobic and anaerobic composting respectively. Aerobic composting reduced DEF levels of 45 ppm to 10 ppm in 8 weeks. Composting of cotton gin trash that had low DEF residues of about 1.3 ppm did not result in lower DEF levels after 8 weeks. Composting did not have any effect on paraquat levels in cotton gin trash.

Arndt et al. (1981) described a study in which they examined the effects of composting garbage on parathion degradation. They could not find any metabolites of parathion after seven days of composting and concluded that composting was not effective in degrading parathion.

In contrast, Dr. Don Mullins and associates at Virginia Polytechnic Institute have been experimenting with the effects of composting on diazinon and chlordane. Dr. Mullins graciously supplied me with a copy of an in press manuscript of their work for inclusion in this discussion. He will also be presenting a poster presentation of his work during this workshop. In their work they used a bench-top system for composting dairy cow manure and sawdust and added radiolabelled diazinon and chlordane to the compost media to achieve concentrations of 100 pmm. The compost was incubated for three weeks and then analyzed. They found that approximately 15% of the diazinon was lost due to volatilization, and that the remaining radioactivity in the soil was not associated with diazinon, but a hydrolysis product IMHP (2-isopropyl-4-methyl-6-hydroxypyrimidine). The loss of chlordane from the compost was approximately 50% through volatilization, and there was virtually no measurable metabolism.

Dr. Mullins also informed me that they have performed some field studies using peat amended with ground corn as the compost media, and that this combination is very effective in degrading very high concentrations of diazinon. This area of research should provide some very useful data in the future, and due to the low cost of the ingredients, would be economically feasible for small operators.

Enzymatic Methods:

Munnecke (1976 and 1980) described his efforts to degrade organophosphate pesticides using enzymatic systems derived from mixed bacterial cultures grown on parathion as the sole source of energy and carbon. He found that his crude cell extracts and crude enzyme extracts when added to solutions of various organophosphates, promoted hydrolysis of the pesticides at a faster rate than chemical hydrolysis. While the hydrolysis of organophosphates is not a complete detoxification, it does provide a significant reduction in toxicity.

Honeycutt et al. (1984) utilized parathion hydrolase purified by Dr. Munnecke in further studies on the degradation of high concentrations of diazinon in soil. Their studies simulated situations in which spills of diazinon would result in localized, high concentrations of pesticide in the soil. They found that parathion hydrolase was very effective in promoting the hydrolysis of diazinon at levels as high as 5000 ppm. They found that the enzyme preparation hydrolyzed diazinon several times faster than a chemical hydrolysis method using sodium hydroxide. Their results indicate that this enzyme preparation may indeed have a practical use as a method for rapidly detoxifying spills of organophosphate pesticides.

Microbial Acclimation and Genetic Engineering:

Microbes can be acclimated to utilize pesticides as a carbon source by growing them in increasingly higher concentrations of pesticide. This has been done for 2,4-dichlorophenoxyacetic acid and 2,4-dichlorophenol (Tyler and Finn, 1974), DDT (Francis et al. 1976) and parathion (Daughton and Hsieh, 1977). The focus of this research has been to acclimate the microbes so that they can tolerate extremely high levels of the pesticide and thus be useful in treating concentrated waste such as pesticide spills. One limitation of this research is that it usually has focused on a single pesticide rather than mixtures of pesticides. Theoretically, a low level acclimatization of this type should take place in disposal facilities like the Iowa State University and University of California systems.

Another promising area of research is the genetic engineering of bacteria to degrade organic pollutants. One aspect of genetic engineering involves the transfer of plasmids from one bacteria species to another. Plasmids are small, extrachromosomal, closed DNA molecules that can replicate. Plasmids usually code for a special function such as antibiotic resistance, or chemical degradation. Pseudomonas species, commonly found in soils, have been most extensively examined for degradative plasmids and at least 8 have been found so far (Quensen and Matsumura, 1984). These plasmids may be passed from one bacteria to another naturally, or "engineered" into another bacteria. Quensen and Matsumura (1984) have recently shown that the chemical degradative capacity of one Bacillus species can be transferred partially to another Bacillus species. This area of research could well lead to the development of bacteria that would have the capacity to metabolize many different pesticides and that would be useful in the treatment of pesticide wastes.

CLEANUP OF PESTICIDE DISPOSAL SITES

The last area that I would like to address this afternoon is the detoxification of existing pesticide waste disposal sites that may be a hazard to the environment. Our involvement in this began in September of 1980 with the discovery of such a site at a county airport that had been used by an aerial applicator for over 10 years. During that time equipment washwater and unused spray solution had been washed into the airport drainage system which emptied into an eight foot deep ditch and holding pond over four hundred feet long. Figure 11 shows the results of analysis of samples taken at the mouth of the outlet pipe into the ditch. The California Department of Health Services and Regional Water Quality Control Board mandated the cleanup of this site and we were contacted by the county to find a realistic method to accomplish this. After considerable sampling to establish that the site was not currently contaminating local groundwater, and negotiation with state regulatory agencies, we began an experimental on-site detoxification test that continues to this day.

The first step in the detoxification was the addition of lime to promote the breakdown of the organophosphates which were considered to be the most acute hazard. The second step was the establishment of a test plot to study the breakdown of toxaphene, the most persistent pesticide found there. A three year study conducted by Mirsatari, 1978, had shown that toxaphene was very resistant to aerobic degradation even in organic matter amended non-sterilized soils. In non-sterilized, organic matter amended soil under anaerobic conditions (or flooding) degradation was 80% effective in a matter of seven weeks. Soils which had been autoclaved and amended with organic matter did not degrade toxaphene to any measurable extent nor did soils not amended with organic matter. Therefore, based in large part on the Masatari study, it was decided to amend the contaminated test plot with cow manure followed by rototilling, flooding, and covering the area with polyethylene plastic to promote anaerobic conditions which had been shown to be conducive to toxaphene metabolism. The results of the test plot studies is shown in Figure 12.

Based on the results of this field trial, the entire ditch was amended with manure prior to the winter rainy season. Monitoring wells were drilled to check for groundwater contamination and none has been found at any time over the last four years. The results of this decontamination procedure have been complicated by the fact that the pipes draining the airport are quite long (about 100 yards) and continue to bring pesticide waste into the ditch each rainy season. We can say without reservation that the treatment process has not promoted movement of pesticide into groundwater, and has contributed to the biological metabolism of toxaphene (based on capillary column GLC analysis). We will begin trials at another similar but more controlled site later this year. With further refinement, this procedure may be a very effective, safe and inexpensive alternative to the all too common practice of soil removal to a hazardous waste disposal landfill.

CONCLUSIONS

Biological methods of pesticide waste detoxification are effective and may provide for the complete detoxification of pesticide waste. The activated sludge and trickling filter processes used by industry, while practical for manufacturing operations, are not practical alternatives for the small generator because of the intensive management they require. The disposal beds used by Iowa State University and the University of California both appear to be effective, safe methods of pesticide waste disposal. These systems incorporate biological, chemical and evaporation processes into an integrated system. The regulatory constraints on these systems may be the biggest hindrance to their use since they are technologically and economically feasible. The composting procedure being investigated at VPI holds promise for the future as do enzymatic methods of detoxification and genetic engineering.

More is known of the environmental fate of pesticides than any other class of chemicals. This wealth of information makes it possible to design systems for the detoxification of pesticide wastes that take advantage of the susceptibility of these chemicals to degradation. Biological pesticide detoxification methods offer a variety of techniques that can be used in the overall process. Because of the diversity of chemicals in use as pesticides, it is very unlikely that any one method of degradation will be able to handle all types of waste. By combining chemical, biological, and physical treatments it should be possible to develop pesticide waste disposal systems that can fill all needs.

From a practical point of view, more laboratory and field research must be done to integrate all of the disposal technologies currently available into economical and environmentally safe methods of DPS disposal. All parties involved in pesticide use, industry, state and federal government agencies and commercial users should contribute to this research effort if it is to be successful.

REFERENCES:

Arndt, W.; Schindlbeck, E.; Parlar, H. and Korte, F. Behavior of Organophosphorus Insecticides in Garbage and Waste Composting (Degradation, Environmental Contamination). Chemosphere 10(9):1035-1040, 1981.

Atkins, P.R. "The Pesticide Manufacturing Industry - Current Waste Treatments and Disposal Practices." U.S. Environmental Protection Agency, 12020, Jan. 1972.

Coley, G. and Stutz, C.N. Treatment of Parathion Wastes and other Organics. Journal WPCF, pg. 1345-1349, August 1966.

Daughton, C.G. and Hsieh, D.P.H. Accelerated Parathion Degradation in Soil by Inoculation with Parathion-Utilizing Bacteria. Bull. Environm. Contam. Toxicol. 18(1):48-56, 1977.

Doyle, R.C.; Kaufman, D.D. and Burt, G.W. Effect of Dairy Manure and Sewage Sludge on ^{14}C-Pesticide Degradation in Soil. J. Agric. Food Chem. 26(4):987-999, 1978.

Francis, A.J.; Spanggord, R.J.; Ouchi, G.I.; Bramhall, R. and Bohon, N. Metabolism of DDT Analogues by a Pseudomonas sp. Appl. Environ. Microbiol. 32:213-216, August 1976.

Hall, C.V. et al. "Safe Disposal Methods for Agricultural Pesticide Wastes." U.S. Environmental Protection Agency, EPA 600/2-81-074, May 1981.

Hall, C.V. Pesticide Waste Disposal in Agriculture in "Treatment and Disposal of Pesticide Wastes"; Krueger, R.F.; Seiber, J.N., Eds.; American Chemical Society, Washington, D.C., 1984; Chap. 3.

Honeycutt, R.; Ballantine, L.; LeBaron, H.; Paulson, D.; Seim, V.; Ganz, C. and Milad, G. Degradation of High Concentrations of a Phosphorothioic Ester by Hydrolase in "Treatment and Disposal of Pesticide Wastes"; Krueger, R.F.; Seiber, J.N., Eds.; American Chemical Society, Washington, D.C., 1984; Chap. 20.

Howe, R.H.L. Toxic Wastes Degradation and Disposal. Process Biochemistry, pg. 25-28, 37, April 1969.

Johnson, L.M. and Hartman P.A. Microbiology of a Pesticide Disposal Pit. Bull. Environm. Contam. Toxicol. 25:448-455, 1980.

Junk, G.A. and Richard, J.J. Pesticide Disposal Sites: Sampling and Analysis in "Treatment and Disposal of Pesticide Wastes"; Krueger, R.F.; Seiber, J.N., Eds.; American Chemical Society, Washington, D.C., 1984; Chap. 5.

Klein, S.A.; Jenkins, D.; Wagenet, R.J.; Biggar, J.W. and Yang, M-S. "An Evaluation of the Accumulation, Translocation, and Degradation of Pesticides at Land Wastewater Disposal Sites." U.S. Army Medical Research and Development Command, Washington, D.C. National Technical Information Service AD/A-006551, Nov. 1974.

Lue-Hing, C. and Brady, S.D. Biological Treatment of Organic Phosphorus Pesticide Waste-Waters. Purdue Univ. Eng. Ext. Ser. 132 (pts. 1/2):1166-1177, 1968.

Mirsatari, S.G. Some Characteristics of Toxaphene Residues on Foliage and in Soil and Sediment. Ph.D. Thesis Abstract, University of California, Davis, 1978

Montgomery, M.L.; Klein, D.; Goulding, R. and Freed, V.H. Biological Degradation of Pesticide Wastes. Pesticide Chemistry; Proceedings 6:117-125, 1972.

Munnecke, D.M. Chemical, Physical, and Biological Methods for the Disposal and Detoxification of Pesticides. Residue Reviews 70:1-26, 1979.

Munnecke, D.M. Enzymatic Detoxification of Waste Organophosphate Pesticides. J. Agric. Food Chem. 28(1):105-111, Jan/Feb 1980.

Munnecke, D.M. Enzymatic Hydrolysis of Organophosphate Insecticides, a Possible Pesticide Disposal Method. Applied Environ. Microbiol. 32(1):7-13, July 1976.

Petruska, J.A.; Mullins, D.E.; Young, R.W. and Collins, E.R., Jr. A Benchtop System for Evaluation of Pesticide Disposal by Composting. Nuclear and Chemical Waste Management. In press.

Quensen, J.F., III and Matsumura, F. Transfer of Degradative Capabilities: Bacillus megaterium to Bacillus subtilis by Plasmid Transfer Techniques in Evaporation Beds in "Treatment and Disposal of Pesticide Wastes"; Krueger, R.F.; Seiber, J.N., Eds.; American Chemical Society, Washington, D.C., 1984; Chap. 19.

SCS Engineers, Long Beach, CA. "Disposal of Dilute Pesticide Solutions." U.S. Environmental Protection Agency, EPA/SW-174c, 1979.

Seiber, J.N.; Winterlin, W.W.; McChesney, M. and Roati, S.B. Behavior of Chemical Residues during Screening, Composting and Soil Incorporation of Cotton Gin Wastes. Proceedings of Gin Waste Utilization, Roundup and Tour, University of California Cooperative Extension, Hanford-Kings County, Feb. 5, 1981.

Stojanovic, B.J.; Kennedy, M.V. and Shuman, F.L., Jr. Edaphic Aspects of the Disposal of Unused Pesticides, Pesticide Wastes, and Pesticide Containers. J. Environ. Quality 1(1):54-62, 1972.

Tyler, J.E. and Finn, R.K. Growth Rates of a Pseudomonad on 2,4-Dichlorophenoxyacetic Acid and 2,4-Dichlorophenol. Appl. Microbiol. 28(2):181-184, August 1974.

Winterlin, W.L.; Schoen, S.R. and Mourer, C.R. Disposal of Pesticide Wastes in Lined Evaporation Beds in "Treatment and Disposal of Pesticide Wastes"; Krueger, R.F.; Seiber, J.N., Eds.; American Chemical Society, Washington, D.C., 1984; Chap. 6.

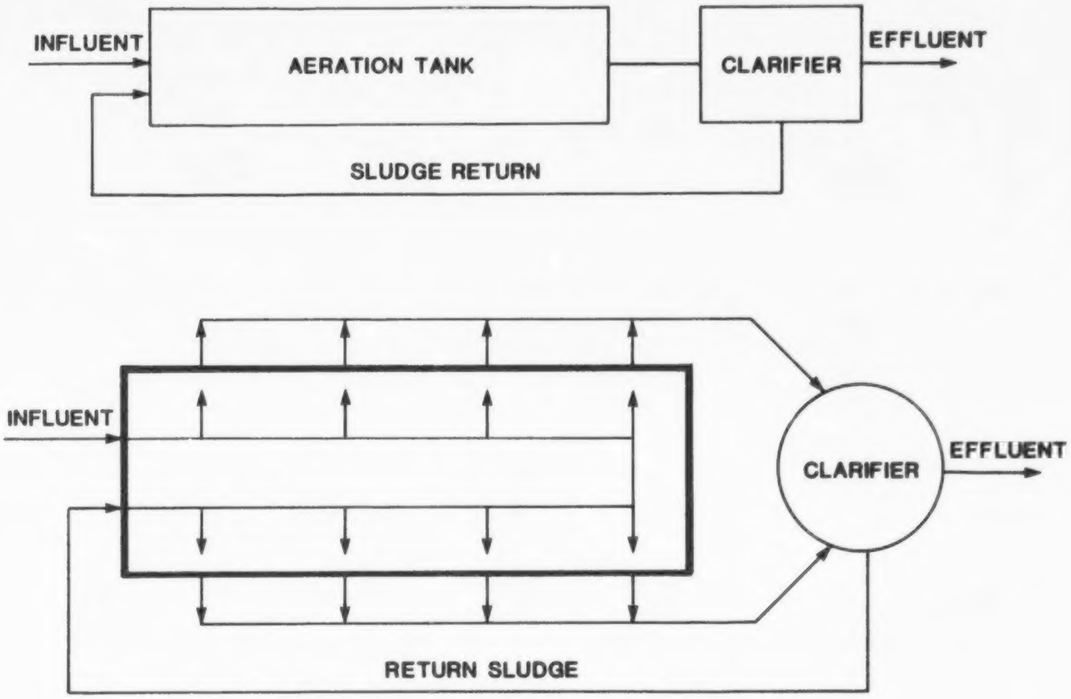

INFLUENT
AERATION TANK
CLARIFIER
EFFLUENT
SLUDGE RETURN
INFLUENT
CLARIFIER
EFFLUENT
RETURN SLUDGE

Figure 1. Activated Sludge System (Taken from SCS Engineers, Long Beach, CA. "Disposal of Dilute Pesticide Solutions." U.S. Environmental Protection Agency, EPA/SW-174c, 1979.)

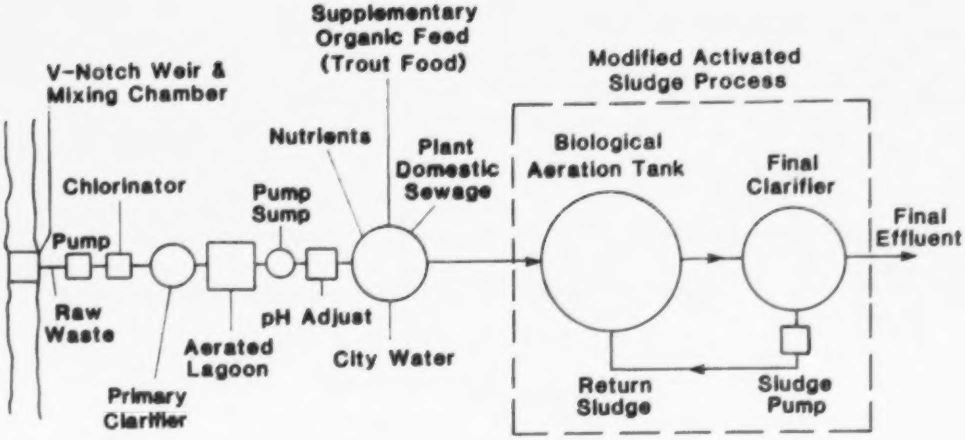

Supplementary Organic Feed (Trout Food)
V-Notch Weir & Mixing Chamber
Modified Activated Sludge Process
Nutrients
Plant Domestic Sewage
Biological Aeration Tank
Final Clarifier
Chlorinator
Pump Sump
Pump
Final Effluent
Raw Waste
pH Adjust
Aerated Lagoon
City Water
Primary Clarifier
Return Sludge
Sludge Pump

Figure 2. Monsanto activated sludge system for biodegradation of paration manufacturing wastes. (Taken from Lue-Hing, C. and Brady, S.D. Biological Treatment of Organic Phosphorus Pesticide Waste-Waters. Purdue Univ. Eng. Ext. Ser. 132 (pts. 1/2):1166-1177, 1968.)

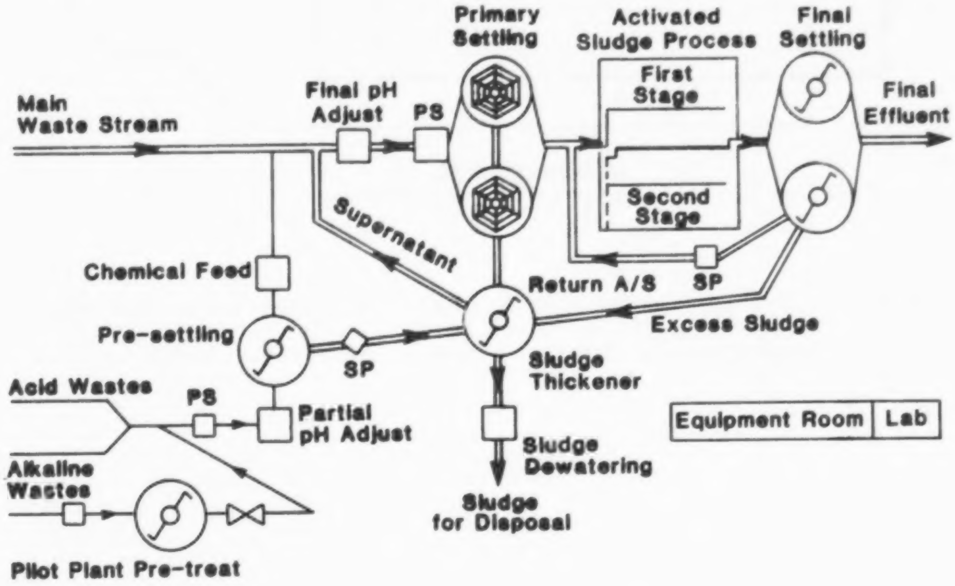

Primary Settling
Activated Sludge Process
Final Settling
First Stage
Main Waste Stream
Final pH Adjust
PS
Final Effluent
Second Stage
Supernatant
Chemical Feed
Return A/S
SP
Pre-settling
Excess Sludge
SP
Sludge Thickener
Acid Wastes
PS
Partial pH Adjust
Equipment Room
Lab
Alkaline Wastes
Sludge Dewatering
Sludge for Disposal
Pilot Plant Pre-treat

Figure 3. Chemagro Corporation activated sludge system for biodegradation of a mixture of organophosphate manufacturing wastes. (Taken from Lue-Hing, C. and Brady, S.D. Biological Treatment of Organic Phosphorus Pesticide Waste-Waters. Purdue Univ. Eng. Ext. Ser. 132 (pts. 1/2):1166-1177, 1968.)

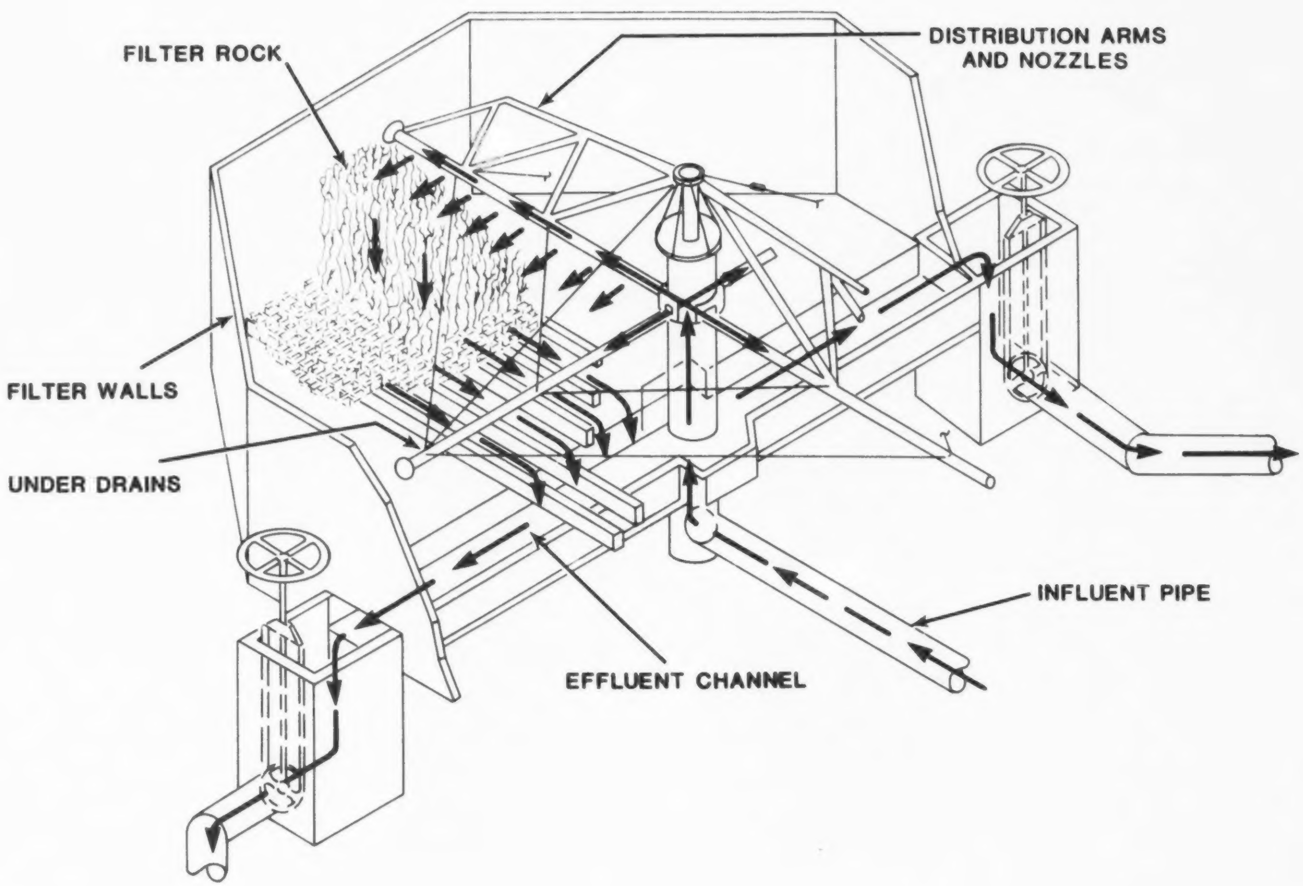

FILTER ROCK
DISTRIBUTION ARMS AND NOZZLES
FILTER WALLS
UNDER DRAINS
INFLUENT PIPE
EFFLUENT CHANNEL

Figure 4. Trickling filter system. (Taken from SCS Engineers, Long Beach, CA. "Disposal of Dilute Pesticide Solutions." U.S. Environmental Protection Agency, EPA/SW-174c, 1979.)

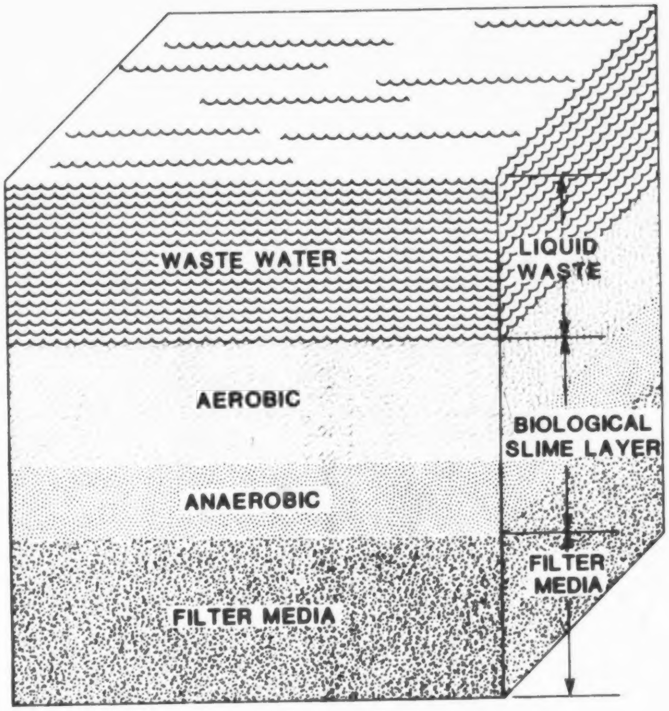

WASTE WATER
LIQUID WASTE
AEROBIC
BIOLOGICAL SLIME LAYER
ANAEROBIC
FILTER MEDIA
FILTER MEDIA

Figure 5. Biological slimes in a trickling filter system. (Taken from SCS Engineers, Long Beach, CA. "Disposal of Dilute Pesticide Solutions." U.S. Environmental Protection Agency, EPA/SW-174c, 1979.)

BIOLOGICAL TREATMENT COST ESTIMATES*

Basis for Calculation

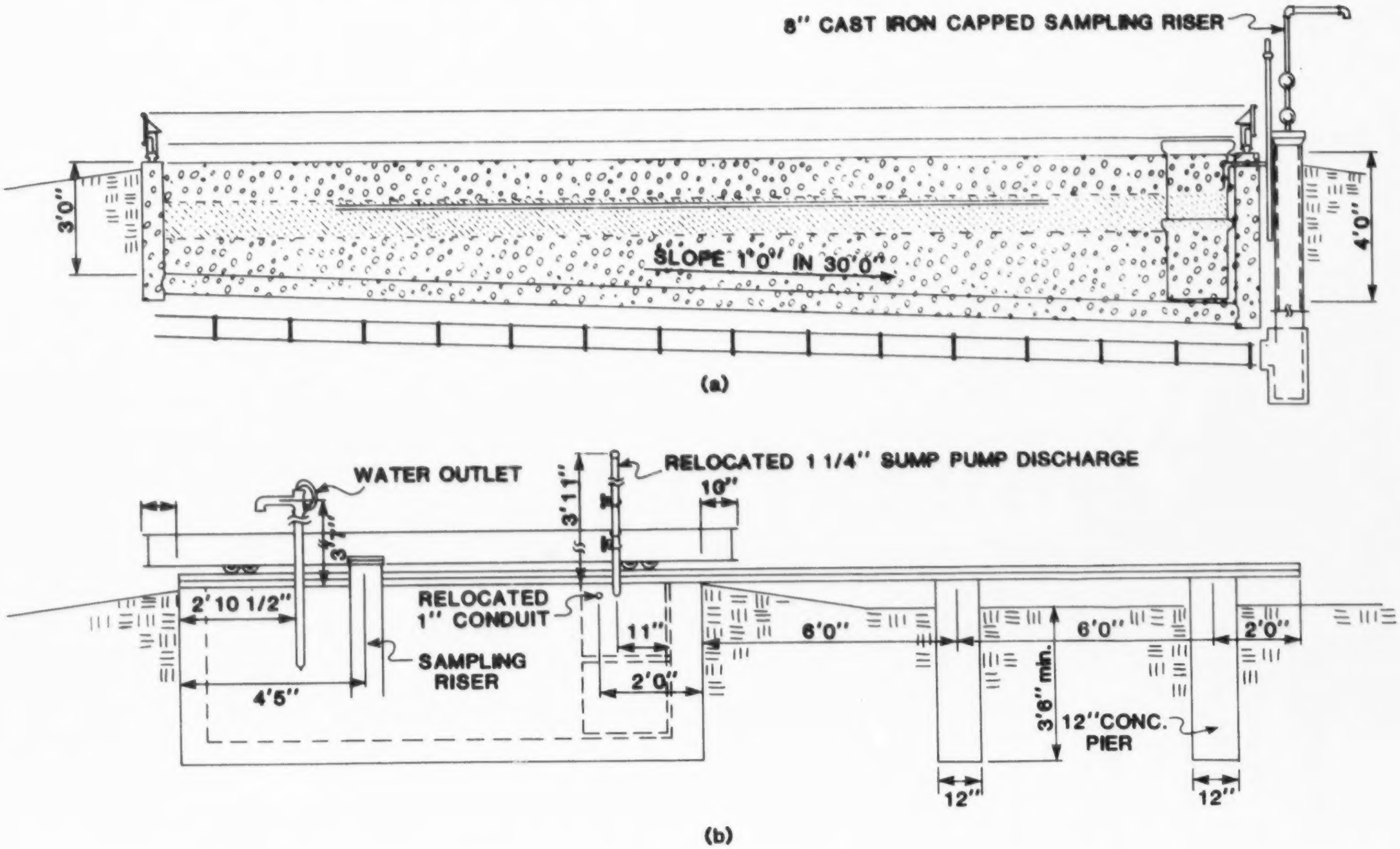
1.7 m^3 (450 gal)/day
385 m^3 (102,000 gal)/yr
225 operating days/yr

Capital Costs	Activated Sludge		Trickling Filter
Holding tank	$1,750		$1,750
Pump	600		600
Reaction tank	4,500	Trickling filter	4,000
Aeration pump system	1,500	Recirculation system	2,500
Sludge recirculation system	2,500		2,500
Pretreatment system	8,300		8,300
Piping	1,750		1,750
Fencing	700		700
Total	$21,600		$19,600
Yearly Operating Costs			
Monitoring	$600		$600
Electricity	300		300
Checmicals	1,200		1,200
Labor (1,000 hr @ $12/hr)	12,000		12,000
Fixed charges (25% of capital cost)	5,400		4,900
Sludge disposal	1,500		750
Total	$21,000		$19,750
Operating cost per m^3 -	$54.54		$51.30
per gal -	$0.20		$0.19

---

* Equipment and operating cost are based on Menas Building Construction Cost Data 1978.

Figure 6. Cost estimates for activated sludge and trickling filter systems. (Taken from SCS Engineers, Long Beach, CA. "Disposal of Dilute Pesticide Solutions." U.S. Environmental Protection Agency, EPA/SW-174c, 1979.)



8" CAST IRON CAPPED SAMPLING RISER
3'0"
4'0"
SLOPE 1'0" IN 30'0"
(a)
WATER OUTLET
RELOCATED 1 1/4" SUMP PUMP DISCHARGE
10"
3'11"
3'7"
RELOCATED 1" CONDUIT
2'10 1/2"
SAMPLING RISER
4'5"
11"
2'0"
6'0"
6'0"
2'0"
3'6" min.
12"CONC. PIER
12"
12"
(b)

Figure 7. Cross-section of Iowa State University pesticide waste disposal bed. (Taken from Hall, C.V. et al. "Safe Disposal Methods for Agricultural Pesticide Wastes." U.S. Environmental Protection Agency, EPA 600/2-81-074, May 1981.)

Compound

Alachlor
Atrazine
Azinphos methyl
Benomyl
Bensulide
Butralin
Captan
Carbaryl
Chlorothalonil
Chloroxuron
Citcop
2,4-D
2,4-DB
DCPA (Dacthal)
Diathane M-22, M-45, and Z-78
Dicamba
Dichlobenil
Diphenamid
Endosulfan I and II
EPTC (Eptam)
Ethylparation
Folpet
Glyphosate

Compound

Guthion
Heptachlor
Hexachlorobenzene
Kelthane
Lannate
Malathion
Mancozeb
Maneb
MCPP
Methomyl
Methoxychlor
Metribuzin
Naptalam
Omite
Paraquat dichloride
Penoxalin
Phosmet
Polyram
Propachlor
Simazine
Sulphur
Trifluralin

Figure 8. Types of pesticide wastes disposed into Iowa State University Horticulture Station Pesticide disposal Bed (Taken from Hall, C.V. Pesticide Waste Disposal in Agriculture in "Treatment and Disposal of Pesticide Wastes"; Krueger, R.F.; Seiber, J.N., Eds.; American Chemical Society, Washington, D.C., 1984; Chap. 3.)

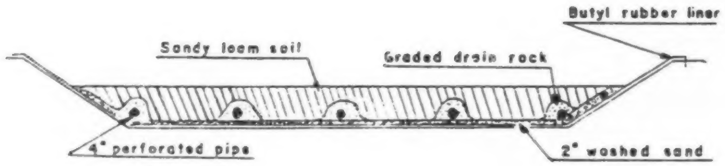


Figure 9. Cross-section of a University of California pesticide wastewater disposal bed. (Taken from Winterlin et. al. Disposal of Pesticide Wastes in Lined Evaporation Beds, in "Treatment and Disposal of Pesticide Wastes"; Krueger, R.F.; Seiber, J.N., Eds.; American Chemical Society, Washington, D.C., 1984; Chap. 6.)

SOIL MOUNDS AND PITS COST ESTIMATES*

Basis for Calculations

1.7 m^3 (450 gal)/day
385 m^3 (102,000 gal)/yr
225 operating days/yr

Capital Costs	Soil Mound	Soil Pit
Holding tank	$1,750	$1,750
Pump	600	600
Distribution box	50	--
Pit, concrete liner, backfill (6m x 12m x 1m)	7,500	7,500
Leach lines	450	--
Gravel, soil	50	50
Roof	1,750	1,750
Fencing	700	700
Total	$12,850	$12,350

Yearly Operating Costs	Soil Mound	Soil Pit
Monitoring	$2,400	$2,400
Electricity	100	100
Labor (250 hr @ $11/hr)	2,750	2,750
Fixed charges (25% of capital costs)	3,212	3,087
System clean-up and spent soil disposal (prorated over 10 yr)	1,240	1,240
Total	$9,702	$9,577
Operating costs per m^3 -	$25.20	$24.88
per gal -	$0.095	$0.09

---

* Based on Means Building Construction Cost Data in 1978.

Figure 10. Cost estimates of Iowa State University and University of California pesticide wastewater disposal beds. (Taken from SCS Engineers, Long Beach, CA. "Disposal of Dilute Pesticide Solutions." U.S. Environmental Protection Agency, EPA/SW-174c, 1979.)

PESTICIDE LEVELS IN SOIL SAMPLES TAKEN DIRECTLY BELOW DRAIN PIPE OUTLET (PPM)

Pesticide	Top 1'	1'-2' depth
Dacthal	300-1000	1
Diazinon	60-80	1
Parathion	300-500	1
Toxaphene	200-750	20
Dursban	200	5
2,4-D	30	10-20

Figure 11. Pesticide contamination at the outflow pipe of airport drainage system.

TOXAPHENE CONCENTRATION IN SOIL SAMPLES REMOVED FROM MANURE AMENDED TEST PLOTS (PPM)

Date	Day Number	Toxaphene Concentration
10/07/80	0	62
10/14/80	7	45.9
10/22/80	15	43.2
10/31/80	24	40.2
11/7/80	31	38.9
1/2/81	85	27.8
2/1/81	117	23.4

Figure 12. Results of soil amendment with manure in the airport drainage system test plots. Half-life of toxaphene in the test plots was calculated to be 98.7 days.

CHEMICAL TREATMENT OPTIONS FOR PESTICIDE WASTES DISPOSAL

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ABSTRACT

The development of chemical means of detoxification of pesticide wastes and spills is an increasingly important endeavor for the pesticide industry. The objective of this paper is to review some of the chemical degradation methods for pesticide decontamination that exist today. In presenting each method, less emphasis has been put on technical detail of the method and more emphasis has been put on the cost of the method, regulatory attractiveness, and simplicity to potential users of the method. Some methods that will be discussed are microwave plasma destruction, photolysis, hydrolysis, ozonation, wet air oxidation, chemical fixation, and reductive degradation. Recent screening experiments carried out by the Product Neutralization Task Force at CIBA-GEIGY on the chemical destruction of several of our pesticides show that household bleach (NaOCl) is effective over a broad range of chemicals. Further, results show that for some chemicals, biological destruction or other means of detoxification would be preferred over chemical means. Details of these studies will be discussed.

INTRODUCTION

Pesticide wastes and pesticide spills are becoming an increasingly visible problem throughout the world. Pesticide spills can be both hazardous to the environment and to man, expensive to clean up, and result in adverse publicity for the manufacturer. An example of such a spill occurred recently in the Midwest. In this case several hundred gallons of a liquid concentrate was discharged after a plug broke on a storage tank. Clean up of the resulting water contamination cost about $150,000, mainly due to the cost for resin and the expensive equipment brought in to clean up the spill. Since the manufacturers of pesticides are generally responsible for clean up of spills, it is clearly advantageous and profitable for the manufacturers to provide inexpensive and effective means to decontaminate pesticide discharges into the environment. Pesticide waste from farm activities results usually in smaller spills, but are of equal importance, since contamination of surface or groundwater may result. Currently there are few, if any, widely accepted methods to decontaminate soil or contaminated water resulting from rinsates of spray tanks which may be discarded.

PURPOSE

The objective of this presentation is to review some of the available chemical methods for decontamination of pesticide wastes and spills. I will avoid getting into technical detailed kinetic descriptions of these methods and attempt to deal with 1) a brief description of the method, and 2) an evaluation of its complexity in terms of cost and simplicity to the potential users of the method. I will also present some recent results of chemical degradation studies which we have carried out on some of our products at CIBA-GEIGY Corporation.

HISTORICAL PERSPECTIVE

Several chemical techniques are available for degradation of pesticide wastes. Dillon (1) has published an extensive review of these techniques in the book, Pesticide Disposal and Detoxification (1981) - Chapter 6. Dillon categorizes existing physicochemical methods as to the type of material phase that is encountered:

I. Gas Phase Methods
   A. Microwave Plasma Destruction
   B. Photolysis

II. Liquid Phase Methods
   A. Activated Carbon and Resin Adsorption
   B. Hydrolysis and Simple Chemical Treatment
   C. Molten Salt Baths
   D. Ozonation Technique
   E. Wet Air Oxidation

III. Liquid - Solid Phase Method/Chemical Fixation

IV. Catalytic Liquid Phase Methods
   A. Catalytic Dechlorination
   B. Reductive Degradation

In order to stay within the scope of this paper, I will discuss only the chemical techniques outlined by Dillon.

GAS PHASE METHODS

Microwave Plasma Destruction: Microwave plasma destruction employs an apparatus as shown in Figure 1. The organic material is channeled through a plasma detector tube where destruction is initiated by microwave radiation producing electrons. The electrons react with the organic molecules to form free radicals and final simple reaction products such as SO_2, CO_2, CO, H_2O, HPO_3, $COCl_2$, Cl_2O, and Br_2. For example, the overall reaction for malathion is:

$$\text{Plasma} + C_{10}H_{19}O_6PS_2 + 15O_2 + 2SO_2 + 10CO_2 + 9H_2O + HPO_3$$

The plasma method results in an extensive detoxification for several pesticides as shown in Table 1. Detoxification levels of 99+% are achieved at 0.18 to 3 kg/hr. The microwave plasma method is relatively expensive (0.50 dollars/kg detoxified) and would not be a simple devise for farmers to use for disposal of rinsates. However, production facilities may find such a devise extremely effective for decontamination of effluents and will have to weigh costs vs. effectiveness of alternatives. Further, safety evaluations have to be made for the discharge of the products into the environment.

PHOTOLYSIS

Pesticides undergo many types of photolysis reactions such as ring fusion, condensation, bond rearrangement reductive loss of chlorine, replacement of chlorine by hydroxyl groups and replacement of halogens by phenyl groups. Figure 2 shows some examples of photolytic reactions that take place with pesticides. One of the most practical applications of photolysis to pesticide decontamination is that of the photodegradation of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD). TCDD in herbicide orange is photolyzed in sunlight with a $t_{1/2}$ of 6 hours. To date, photolysis has not been applied to clean up of spills or rinsates.

LIQUID PHASE METHODS

Activated Carbon and Resin Adsorption: Adsorption processes are used widely to cleanup chemical spills and to clean up low concentrations of unwanted chemicals in waste streams. Generally, solutions of chemicals should be <1,000 ppm when employing adsorption processes. Costs of using adsorption processes are high (generally $1.33/1,000 liters of pesticide plus considerable capital investment), but this process is quite effective. One example, waste streams of 100 ppm chlorophenols have been decontaminated to levels of <1 ppm by carbon adsorption processes.

Hydrolysis and Simple Chemical Treatment: Hydrolysis and chemical treatment are common methods used to clean up pesticide waste streams and spills. Table 2 shows an example of several organophosphate insecticides that were detoxified using various chemical reagents. Kennedy and coworkers found that several reagents could be used to degrade these organophosphates and that the percentage of degradation ranged from 92-100% for the reagents shown in Table 2. Obviously, metallic sodium in liquid ammonia was the most effective, however, the human hazard, corrosive nature and high cost of these reagents would prohibit their use.

When trying to determine which reagent would be the best to decontaminate chemical spills or wastes, an appropach similar to the one used recently at CIBA-GEIGY is recommended. We carried out a series of studies to determine if any one of a number of common simple reagents would degrade a variety of our formulated products. A 10,000-30,000 ppm active ingredient in aqueous suspension of formulated pesticide product was treated with a molar excess of reagent for 24 hours at which time the entire solution was extracted with acetone and aliquots taken for parent analysis. Table 3 shows the results of these studies. Of the seven reagents, hypochlorite appeared to be the most effective. Hypochlorite reduced the active ingredient level by at least 50% for 7 of the 10 products tested. Dual® and Tilt® appear to be the most chemically resistant products since none of the reagents appeared to degrade either product to a significant degree.

These screening studies were cursory in nature and were only used to tell us which products were likely candidates for employment of simple chemical detoxification methods or conversely which chemicals may be more stable and hence candidates for development of biological degradation methods. For the promising reagents, further research will be needed to define the optimum reagent/active ingredient ratio, reaction time, and potential exposure and toxicity of the degradation products.

Molten salt processes: One extremely interesting detoxification process developed by Rockwell International is the molten salt process. Waste material is blown into a large bath (10 ft. high and 3 ft. in diameter) of molten salt at 800-1,000°C. Feed rates are 23-91 kg/hr. Figure 3 shows a schematic of a molten salt combustion process. The overall chemical reaction is:

$$C,H,O,N+O_2 \xrightarrow[\text{iron catalyst}]{\text{molten salt}} CO_2+H_2O+N_2$$

About 99.94% degradation has been achieved at the bench scale for DDT, 2,4-D, and chlordane. The cost for this process has been estimated at $1.10/kg of chemical. A mobile molten salt combustion unit that would decontaminate 230 kg/hr has been proposed by Rockwell International.

Ozonation methods: There are three pesticide chemical degradation methods utilizing ozone gas:

- Ozone/ultraviolet irradiation
- Sonocatalysis
- Catalytic ozonation

Ozone/Ultraviolet Irradiation: Ozone/ultraviolet irradiation processes to degrade pesticides are being developed at several locations around the United States. Houston Research, Inc., Westgate Research Corp., and Pure Water Systems, Inc. are three laboratories pioneering this field.

The chemical reaction of interest with this chemical detoxification process is:

$$\text{PESTICIDE} + O_3 \xrightarrow[H_2O]{\text{UV LIGHT}} CO_2 + H_2O + \text{OTHER SIMPLE SPECIES}$$

Dr. Phil Kearney and coworkers (2), at USDA, Beltsville, Maryland, has explored the practicality of using UV/ozonation methods to decontaminate farm generated pesticide rinsates. Dr. Kearney and coworkers carried out their research at the USDA farm at Beltsville, Maryland, where about 3,000 acres are sprayed annually. In one experiment, the researchers collected spray rinstate from AAtrex® 4L (40.8% ai) and processed it using a mobile UV/ozonation apparatus purchased from Pure Water Systems, Inc., Fairfield, New Jersey. Figure 4 shows some of the results of this study. Atrazine was degraded rapidly with this system. For a 12,000 ppm (ai) solution, 40% degradation was achieved in 30 minutes. It was also found that if the concentration of the active ingredient was reduced, the degradation rate dramatically increased.

The economics of this system has been studied by Kearney, as well. The UV/ozonation unit is $35,000. The cost for running it would come to about $650 annually. This annual cost compares well to incineration, but is more expensive than physical treatment or land disposal. The advantages of the unit are its mobility, relative base of operation, low operating cost, production of less toxic degradation products, and extensive degradation in a short period of time. This last advantage is important since most spills should be cleaned up raidly and toxic materials disposed of rapidly and cheaply.

Zimmerman Process (Wet Air Oxidation): This process utilizes heat (up to 350°C) and pressure (up to 2,500 psig) in the presence of oxygen to oxidize pesticide wastes. Table 4 shows some of the results using wet air oxidation as a chemical decontamination method. Amiben® has been degraded 88-99.5% and atrazine by 100% using this process. The cost of this process relative to other destruction methods applied to pesticides has not been extensively studied.

CATALYTIC LIQUID PHASE METHODS

Catalytic liquid phase methods are of two types: catalytic dechlorination and reductive degradation. I will deal with only reductive degradation in this paper.

Reductive Degradation Metallic Couples: Reductive degradation processes utilize metallic couples such as zinc/copper or iron/copper. Bench scales reduction processes have been tested at 1.7 liters/min. resulting in degradation of 50 ppb chlorinated hydrocarbons in water to 0.02 ppb. This process could have significant application to clean up of contaminated groundwater.

SUMMARY AND CONCLUSIONS

Table 5 shows a summary of the several pesticide degradation processes which were discribed in this paper. Several characteristics of these processes, including degradation products, environmental impact and relative costs, are presented in this table. Of the nine listed processes, the economics of only five has been researched extensively. All five of these processes require considerable capital expenditure. While the UV/ozonation and microwave plasma destruction processes appear to be the most economical of the five, they may be practical for only clean up of industrial wastes such as effluents or large spills. Individual farmers or commercial applicators may find such capital investments hard to justify. More simple, less expensive degradation processes such as chemical treatment or biological treatment may be better suited for decontamination of farm rinsates.

Although considerable progress has been made on chemical processes to clean up chemical spills and wastes, considerable research remains to be done on many of these processes mentioned above. From the variety and complexity of these chemical processes which are now under study, it is easy to see that considerable time and expense will be needed before a final solution to the problem of decontamination of chemical wastes is realized.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the technical assistance of Wayne Barker and Joe Keeney of EN-CAS Laboratories, Winston-Salem, North Carolina.

REFERENCES

1. Dillon, A. P., 1981. Physical and Chemical Disposal Methods. Pesticide Disposal and Detoxification Processes and Techniques. Noyes Data Corporation, Park Ridge, New Jersey, U.S.A. PP. 83-156.

2. Kearney, P. C., Q. Zeng, and John M. Ruth, 1984. A Large Scale UV-Ozonation Degradation Unit-Field Trials on Soil Pesticide Waste Disposal, ACS Symposium Series No. 259 - Treatment and Disposal of Pesticide Wastes, R. F. Krueger and J. N. Seiber, Editors. PP. 195-209.

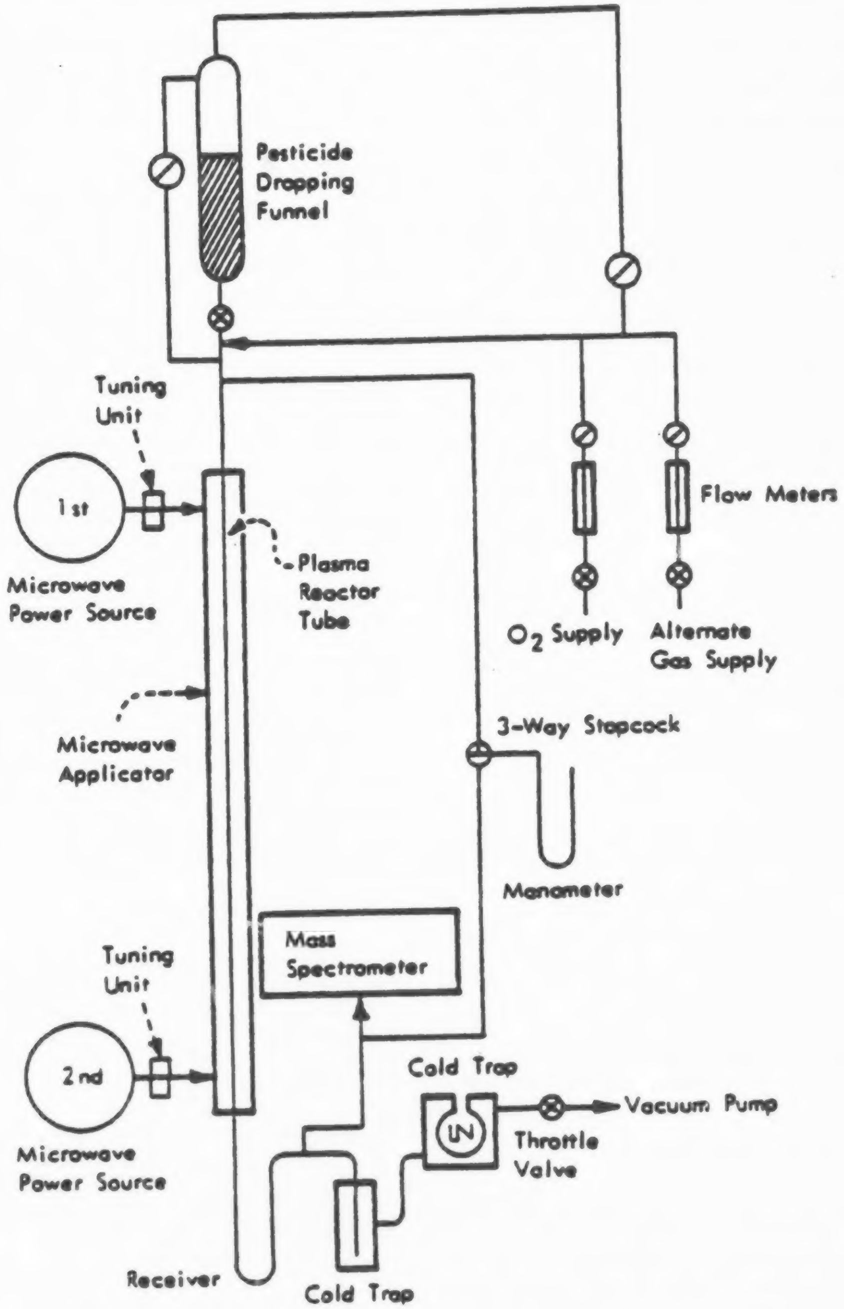
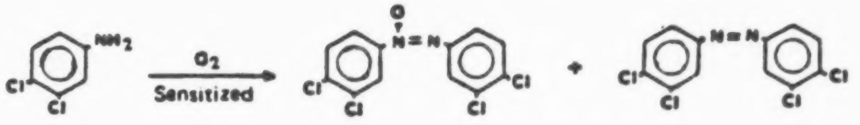
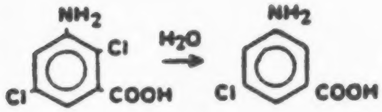

Pesticide
Dropping
Funnel
Tuning
Unit
1st
Microwave
Power Source
Plasma
Reactor
Tube
Flow Meters
O_2 Supply
Alternate
Gas Supply
Microwave
Applicator
3-Way Stopcock
Manometer
Mass
Spectrometer
Tuning
Unit
2nd
Microwave
Power Source
Cold Trap
Vacuum Pump
LN
Throttle
Valve
Receiver
Cold Trap

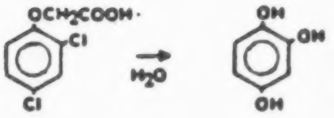
FIGURE 1. SCHEMATIC OF MICROWAVE PLASMA APPARATUS (FROM DILLON, 1981)


NH2
Cl
Cl
O2
Sensitized
O
N=N
Cl
Cl
Cl
Cl
+
N=N
Cl
Cl
Cl
Cl

3,4-DICHLOROANILINE (CONDENSATION)


NH2
Cl
Cl
COOH
H2O
NH2
Cl
COOH

AMIBEN (3-AMINO-2,5-DICHLOROBENZOIC ACID)
REDUCTIVE LOSS OF CHLORINE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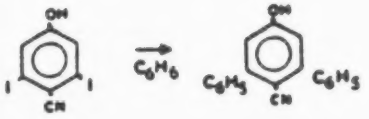
Cl
Cl
H2O
OH
OH
OH

REPLACEMENT OF CHLORINE BY HYDROXYL


OH
I
I
CN
C6H6
OH
C6H5
C6H5
CN

IOXYNIL (4-HYDROXY-3,5-DIIODOBENZONITRILE)
REPLACEMENT OF HALOGEN BY PHENYL

FIGURE 2. PHOTOLYTIC REACTIONS OF PESTICIDES (FROM DILLON, 1981).

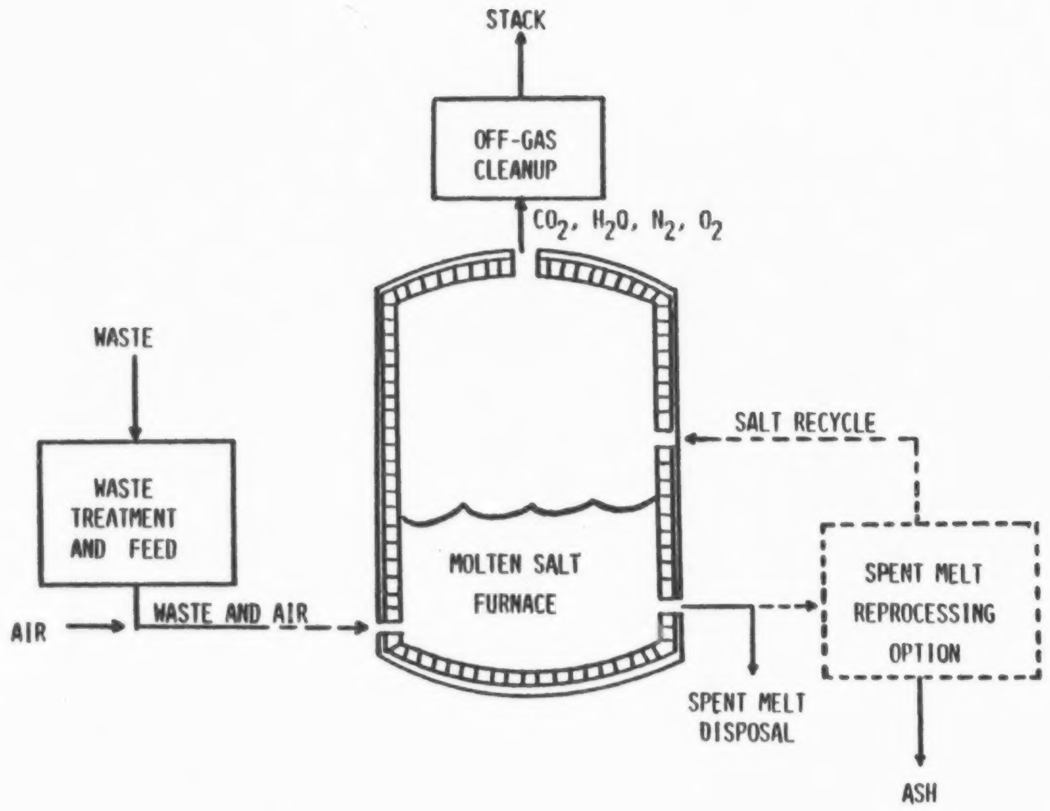

STACK
OFF-GAS CLEANUP
CO_2, H_2O, N_2, O_2
WASTE
WASTE TREATMENT AND FEED
AIR
WASTE AND AIR
MOLTEN SALT FURNACE
SALT RECYCLE
SPENT MELT REPROCESSING OPTION
SPENT MELT DISPOSAL
ASH

FIGURE 3. SCHEMATIC OF MOLTEN SALT COMBUSTION APPARATUS (FROM DILLON, 1981).

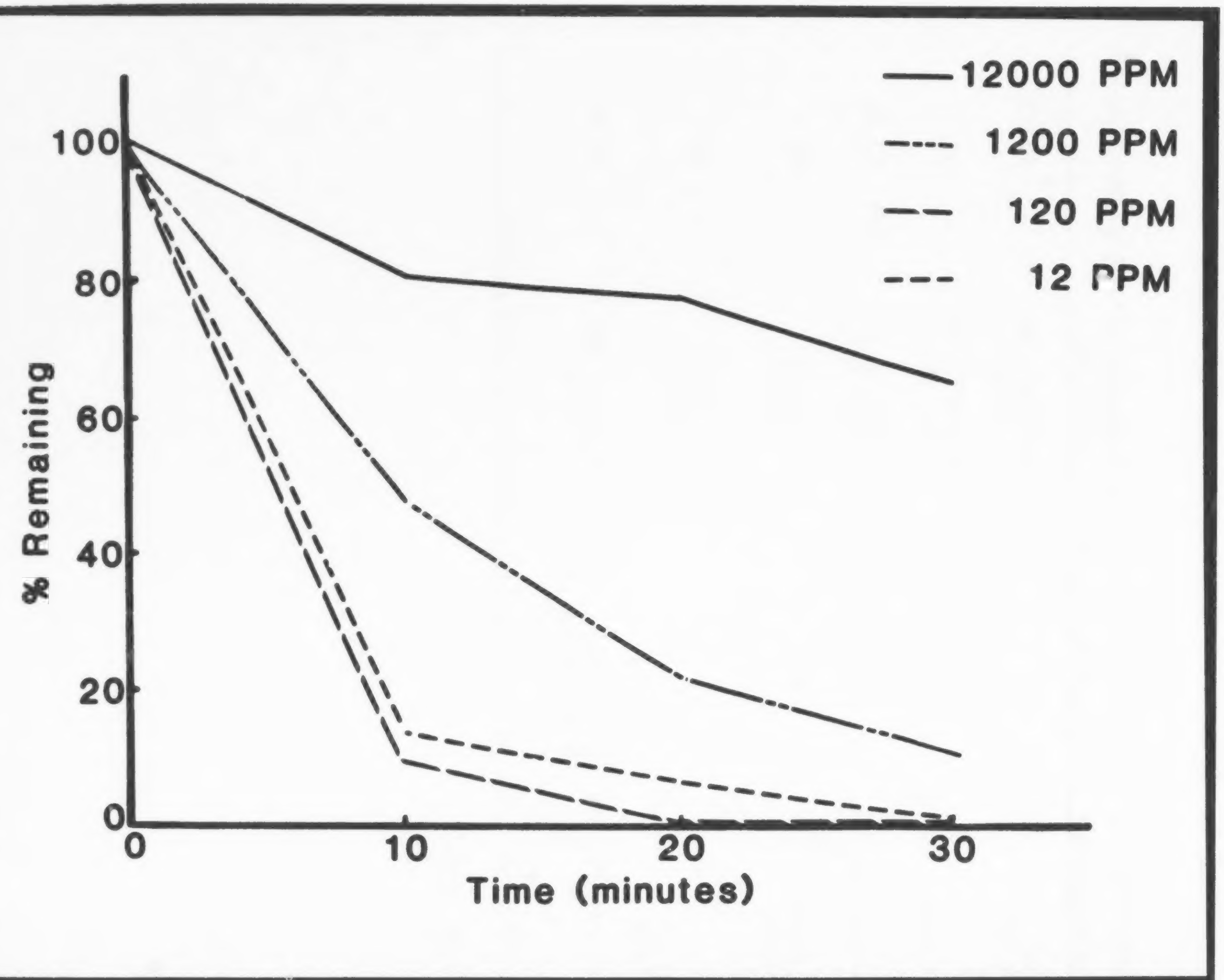


Figure 4 Atrazine U.V. – Ozonation At Various Concentrations. From Kearney Et. Al. 1985.

TABLE 1. SUMMARY OF MICROWAVE OXYGEN-PLASMA REACTIONS

HAZARDOUS MATERIALS	FEED RATE, KG/HR	PRESSURE PA (TORR)	CONVERSION (%)
MALATHION CYTHION® ULV	0.5	3,700-6,100 (28-46)	99.998
PCB AROCLOR® 1242	0.27	2,300-4,700 (17-35)	99
PMA TROYSAN® PMA-30	1.0	16,000-18,700 (120-140)	EST. 99.99
KEPONE® 80/20 20% METHANOL SOLUTION	0.73	7,200 (54)	99
KEPONE® 2 TO 3 G SOLID DISCS	-	930 (7)	99
U.S. NAVY RED DYE	0.5 SLURRY; 0.09 EQUIVALENT	4,600-7,900 (35-60)	99.99

FROM DILLON (1981).

TABLE 2. SUCCESSFUL CHEMICAL DEGRADATION OF OUR ORGANOPHOSPHORUS INSECTICIDES

INSECTICIDES	REAGENT EMPLOYED	PERCENTAGE DECONTAMINATED
DDVP, PARATHION, SCHRADAN, SYSTOX®	METALLIC SODIUM IN LIQUID AMMONIA	100 100
DDVP, SYSTOX, SCHRADAN, PARATHION	METALLIC LITHIUM IN LIQUID AMMONIA	100 97
DDVP	TRIETHANOLAMINE	97
DDVP	IMIDAZOLE	92
SYSTOX	H_2O_2	100
PARATHION	H_2O_2	93

FROM DILLON (1981).

TABLE 3. CHEMICAL DEGRADATION OF CIBA-GEIGY PRODUCTS

		% OF ACTIVE INGREDIENT REMAINING 24 HOURS AFTER TREATMENT					
PRODUCT NAME	WATER CONTROL	5% HCL	5% NAOH	3% H_2O_2	5% NAOCL	FE +5% HCL	LIME SLURRY
TILT® 3.6E	111	97	93	108	105	114	155
CGA-112913 (AI)	102	81	90	80	22	119	42
DUAL® 8E	104	108	105	119	111	114	59
TRIUMPH™ 4E	88	89	59	96	0	96	74
CURACRON® 6E	100	92	0	78	0	96	83
DIAZINON AG500	94	32	77	98	17	43	93
TRIGARD® 75W	123	82	106	127	31	67	129
GALECRON® 4E	87	78	82	74	0	87	149
RIDOMIL® 2E	123	114	0	109	100	112	108
ACARABEN® 4E	106	101	0	110	49	105	77

TABLE 4. WET AIR OXIDATION PESTICIDAL WASTE APPLICATIONS

WASTE SOURCE (SPECIFIC CONSTITUENT)	OPERATING CONDITIONS TEMPERATURE °C	PRESSURE (PSIG)	SPECIFIC CONSTITUENT REMOVED %
AMIBEN® HERBICIDE PROCESS (DICHLORONITROBENZOIC ACID)	280	1,560	>99.5
S-TRIAZINE HERBICIDE PROCESS (ATRAZINE DERIVATIVES)	260	1,200	100

FROM DILLON (1981).

TABLE 5. CHEMICAL DESTRUCTION OF CHEMICAL WASTES AND SPILLS

CHEMICAL PROCESS	PRODUCTS	ENVIRONMENTAL IMPACT OF PROCESS	FEED RATE	COST
MICROWAVE PLASMA DESTRUCTION	SIMPLE CO_2,SO_2 CO,H_2O,HPO_3, $COCL_2$,CL_2,BR_2	MINIMAL SCRUBBERS	20 KG/HR LARGE SCALE	$0.50/KG $100,000 CAPITAL
PHOTOLYSIS	RING FISSION, CONDENSATION LOSS OF HALOGEN HYDROXYLATION	CONSIDERABLE MINIMIZE EXPOSURE AND TOXICITY OF PHOTOPRODUCTS	UNKNOWN	UNKNOWN
ACTIVATED CARBON ADSORPTION	ADSORBED-UNALTERED	MINIMUM DISPOSAL OF ABSORBED CHEMICAL	200 PPM-1 PPM 600,000 L/DAY	$1.33/1,000 LITERS $420,000 CAPITAL
HYDROLYSIS	NOT SIGNIFICANT ALTERATION TO SIMPLE PRODUCTS	CONSIDERABLE MINIMIZE EXPOSURE AND TOXICITY OF PRODUCTS	UNKNOWN	UNKNOWN, LESS EXPENSIVE THAN ENERGY INTENSIVE PROCESS
SIMPLE CHEMICAL TREATMENT	NOT SIGNIFICANT ALTERATION TO SIMPLE PRODUCTS	CONSIDERABLE MINIMIZE EXPOSURE AND TOXICITY OF PRODUCTS	UNKNOWN	UNKNOWN, LESS EXPENSIVE THAN ENERGY INTENSIVE PROCESS

(CONTINUED)

TABLE 5. (CONTINUED)

CHEMICAL PROCESS	PRODUCTS	ENVIRONMENTAL IMPACT OF PROCESS	FEED RATE	COST
MOLTEN SALT PROCESS	SIMPLE, CO_2, H_2O,O_2,N_2	MINIMAL SCRUBBERS PROTECT WORK ENVIRONMENT	23-91 KG/HR	\$1.10/KG \$1,000,000 CAPITAL
UV/OZONATION	MIXED, SIMPLE, E.G., O_2 COMPLEX, E.G., HYDROXY TRIAZINE	MINIMAL CONSIDERABLE MINIMIZE EXPOSURE AND TOXICITY OF PRODUCTS	....	MORE COSTLY THAN CHEMICAL METHODS \$35,000 CAPITAL
WET AIR OXIDATION	CO_2,H_2O	MINIMAL	118 KG/HR	\$0.36/KG \$2,200,000 CAPITAL
REDUCTIVE DEGRADATION	COMPLEX	CONSIDERABLE MINIMIZE EXPOSURE AND TOXICITY TO PRODUCTS	UNKNOWN	UNKNOWN

LAND DISPOSAL OF PESTICIDE RINSATE

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The Environmental Protection Agency (EPA) was formed because of increasing concerns of adverse pollution effects on humans and the environment. One concern is the safe disposal of pesticide rinsate. My discussion focuses on technical and environmental aspects of three disposal options for pesticide rinsate. I will also mention other options. The applicable EPA rules under the Resource Conservation and Recovery Act (RCRA) are also briefly described.

Three disposal options available to generators of a pesticide rinsate are land treatment units, landfills, and surface impoundments. These techniques have many similar, as well as different characteristics. Land treatment is the process of applying waste to the soil surface with a scientific design to degrade, transform, detoxify, and immobilize hazardous waste constituents. Surface impoundments can be designed for treatment or disposal. Landfills are for disposal. Land treatment units and surface impoundments can receive liquids, whereas landfills have controls for disposal of liquid waste. In all three cases it is generally important to know: 1) waste characteristics (e.g., solubility), 2) treatment processes (e.g., biodegradation, photodegradation), and 3) hydrogeologic setting (i.e., soil types and groundwater level and flow characteristics). Advantages and disadvantages of each of these disposal options will be presented.

The discussion of the regulations will: cover definitions of terms which may be unfamiliar; describe what is a hazardous waste, a small quantity generator, and when various rules apply; describe generator and transporter rules for off-site shipments (the manifest system); and describe rules for storage, treatment, and disposal facilities. By the end of the discussion I will have covered acceptable disposal techniques, some of RCRA's requirements, reuse of pesticide rinsate, and other considerations.

INCINERATION OPTIONS FOR DISPOSAL OF WASTE PESTICIDES

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ABSTRACT

This paper presents a summary of a number of EPA's tests of high-temperature incinerators with an overview of their typical waste destruction performance when properly operated. In general, these tests have indicated that current incinerators are capable of effectively destroying most types of organic hazardous wastes including several organic pesticides and a wide variety of industrial/commercial compounds fired either singly or in multi-compound mixtures. However, to date EPA's testing experience has not emphasized the waste disposal problems of the agricultural industry simply because most of the interest and testing dealt with industrial/commercial chemicals. The author's comments concerning incinerating all agricultural pesticide wastes not yet tested must largely be based on extrapolations from incineration test experience from industrial hazardous wastes which have similar chemical and physical characteristics.

Like many industrial hazardous waste streams, agricultural wastes may include a variety of organic and organochlorine compounds and physical forms (e.g., aqueous, non-aqueous wastes, contaminated soils, inerts, or solids, and pumpable and non-pumpable solids. Various types of containers ranging from metal cans or drums to burnable fiber or paper or plastic canisters or bags are also encountered. Certain pesticide formulations, however, may contain various amounts of heavy toxic metals or problem elements (e.g., lead, zinc, mercury, bromine, etc.). These materials may rule out incineration unless suitable pretreatment steps are employed or the metal or, for example, bromine content is either very low or controllable via air pollution control equipment on the incinerator.

EPA has conducted pilot and full-scale incineration tests on a number of actual pesticide types. From these tests plus a much larger data base on many industrial/commercial chemicals including containerized materials, we do not envision many technical limitations in incinerating most organic agricultural pesticides or their containers because of the successful experience thus far with incineration in general.

Regulatory issues regarding incinerating pesticide wastes are similar to other hazardous waste requirements and are discussed briefly.

INTRODUCTION

Although some types of pesticides have already been disposed of by high temperature incineration, the majority of the United States experience and performance data with hazardous waste incineration involves other types of industrial/chemical compounds. Pesticides are specific, sub-categories of the overall system of chemicals known as hazardous or toxic compounds. Pesticides may involve either purely organic molecular structures, or a combination of organic and inorganic structures, where the inorganic fraction may include heavy metals, etc. While many industrial chemicals often fit this same description. Pesticide compounds as a rule tend toward following characteristics:

- Pesticides tend to be somewhat larger and more complex molecules;
- They more frequently involve elements such as sulfur, phosphorus, and/or nitrogen, in addition to chlorine;
- They more often include such heavy metals as lead, mercury, and other halides such as bromine in significant concentrations.

APPROACH

The EPA research indicates that most organic molecules including chlorinated hydrocarbons breakdown into harmless or easily controlled combustion products under sufficient exposure to a high-temperature oxidizing combustion atmosphere. The primary concern still under investigation for organic hazardous chemical waste is what amounts or types of potentially harmful residuals and/or incomplete combustion byproducts may be formed and emitted, should the incinerator operate at less than its normal temperature or oxygen conditions. In the case of well-designed and operated incinerators, input organic compounds including organic pesticides are normally destroyed such that only about 0.01 percent or less by weight of each original compound exits the incinerator stack. The total weight of all identified byproducts or products of incomplete combustion (PIC's) in the stack is normally less than 0.01 percent of the total weight of the input principal organic hazardous constituents (POHC's). Thus, the bulk (i.e., 99.99 percent) of the organic hazardous waste stream is converted to such harmless exhaust products as CO_2 and H_2O under proper operating conditions, plus some amounts of particulate matter. Hydrochloric acid (HCL) is produced from the burning of chlorinated compounds, but is relatively easily scrubbed from stack gases using existing air pollution control technology.

PROBLEMS ENCOUNTERED

The issues involved with incinerating toxic heavy metal-containing compounds or wastes, become much more complicated. Also, halogens other than chlorine (e.g., bromine, iodine), sulfur, or phosphorus potentially present technical problems for conventional incineration. Metals of course are not thermally destroyed by incineration. The fate of metals in an incinerator is basically a function of individual physical properties of boiling point and/or chemical reactivity in the hot zone of the incinerator's combustion chamber. A metal may simply stay behind and become part of the ash; or it may vaporize and recondense in the scrubber, or exit the stack still in vapor form; it could oxidize and either become ash, scrubbed particulate, or escape through the scrubber as a very fine particulate; or the metal may exhibit a combination of all of these behaviors. Potential problems with compounds like bromine and iodine or their hydrogen halides exist as well because they are not nearly as easily scrubbed as HCL has been demonstrated to be. Phosphorus can potentially generate P_2O_5, a toxic compound in itself, and sulfur can present its own acid gas emissions problem.

RESULTS

Pesticide Destruction Results

Of primary importance in this paper is the Agency's actual incineration test data on representative types of pesticides. Over the period from 1974 to the present time, EPA has conducted a number of incineration tests with the specific pesticides listed in Table 1. The listing shows the pesticide common name and type of formulation (e.g., liquid, dust, pellet form, etc.) and the scale or size of the incineration test. Measured destruction efficiency results are also indicated. It should be noted that most pesticides tested were capable of being destroyed to an efficiency of 99.99 percent (4-9's). Exceptions were Mirex and Zineb. In the case of Mirex, investigators felt that destruction could be improved to the 4-9's level with a somewhat more effective incineration design. Zineb exhibited a 4-9's destructive performance of its organic fraction, however, investigators noted that the stack effluent was characterized by a white, cloudy appearance judged to be fine particulate zinc oxide. Despite the use of a three-stage wet scrubbing device, apparently the zine oxide failed to be captured efficiently.

Industrial/Commercial Hazardous Waste Destruction

The EPA has developed a rather comprehensive data base on incineration testing and performance results on a larger number of industrial/organic hazardous wastes. These wastes have been tested in twelve (12) different incinerators. The waste streams studied typically represented the incinerator facility's daily disposal activity. Table 2 presents a summary of chemical compounds in these wastes for which destruction and removal efficiency was determined. Also, a listing of the typical operating conditions noted in the incinerators which destroyed the wastes in Table 2 is presented in Table 3.

The above mentioned list of industrial organic compounds were generally all found to be incinerable to the 99.99 percent or better destruction level in the variety of size and design of incinerators tested by EPA. Only rare exceptions to this rule occurred when a somewhat lower calculated destruction efficiency (i.e., only 99.0 to 99.9 percent) was determined for the following special circumstances.

- °in the cases where the compound concentration in the waste was quite low (e.g., less than 100 ppm);
- °or where solid types of waste were not agitated or retained sufficiently long in the hot zone;
- °where stack gas analyses were made difficult by the fact that the feed compound of interest is also a known breakdown product of incomplete combustion (PIC) of another compound;
- °in cases of deliberate reduction of combustion temperature or air supply where EPA was seeking to determine the operational bounds of effective performance.

Some heavy metals were involved along with the organic chemicals incinerated in Table 2 during EPA's field testing activities. These metals included lead,

TABLE 1

SUMMARY EPA PESTICIDE INCINERATION TEST RESULTS
(References 1, 2, 3, and 7)

Pesticide	Formulation	Scale Of Test	Destruction Efficiency (Of Organic Fraction)
DDT	25% Emulsifiable Conc.	Pilot Scale	99.99%+
DDT	10% Dust	Pilot Scale	99.99%+
DDT	20% Liquid In Diesel Oil	Commercial Scale	99.999%+
Aldrin	41.2% Emulsifiable Conc.	Pilot Scale	99.99%+
Picloram	21.5% Liquid	Pilot Scale	99.99%+
Picloram	10% Pellets	Pilot Scale	99.99%+
Malathion	57% Emulsifiable Conc.	Pilot Scale	99.99%+
Malathion	25% Wettable Powder	Pilot Scale	99.99%+
Toxaphene	60% Emulsifiable Conc.	Pilot Scale	99.99%+
Toxaphene	20% Dust	Pilot Scale	99.99%+
Atrazine	40.8% Liquid	Pilot Scale	99.99%+
Atrazine	90% Wettable Powder	Pilot Scale	99.99%+
Captan	50% Wettable Powder	Pilot Scale	99.99%+
Zineb	75% Wettable Powder	Pilot Scale	99.99%+
Mirex	0.3% Bait	Pilot Scale	98 to 99%
Herbicide Orange	Full Strength*	Full Scale	99.99%+
PCP	0.1% In Wood	Pilot Scale	99.99%+
Kepone	Liquid	Pilot Scale	99.9999%+
Chlordane	Commercial	Pilot Molten Salt	99.99%+

*TCDD in HO above as a 2 ppm contaminant; 50/50 mixture of 2,4,-D and 2,4,5-T.

TABLE 2

TYPICAL INDUSTRIAL ORGANIC HAZARDOUS COMPOUNDS INCINERATED
(References 3, 4, 5, 6, 8, 9, and 10)

PCB
Toluene
Tetrachloroethylene
Trichloroethylene
Carbon Tetrachloride
Naphthalene
Chloroform
Methylene Chloride
Methy Ethyl Ketone
Phenol
Benzene
Butyl Benzyl Phthalate
Bis-(Ethyl Hexyl) Phthalate
Chlorobenzene
1,1,1-Trichloroethane
Aniline
Benzyl Chloride
Diethylphthalate
Phthalic Anhydride
Amines
Chlordane
Chlorobenzenes
Chloromethane
Chloroethanes
Cresol(s)
Dimethyl Phenol
Dodecanol
Hexachlorobutadiene
Hexachlorocyclopentadiene
Isocyanates
Methylene Bromide
Methyl Pyridine
Phosgene Gas

TABLE 3

TYPICAL OPERATING CHARACTERISTICS OF INCINERATORS MEETING REGULATORY REQUIREMENTS ON DESTRUCTION AND REMOVAL EFFICIENCY

Combustion Chamber Temperature Level:	820°C to 1500°C (1500°F to 2700°F)
Residence Time:	0.2 sec to 6.5 sec for gases and liquid/vapors several minutes to 1/2 hour for solids/sludges
Excess Combustion Air:	60 to 130 percent
Stack Gas Composition:	
Oxygen :	8 to 15 percent
Carbon Dioxide :	6 to 10 percent
Carbon Monoxide :	0 to 50 ppm (with rare exceptions up to 500 ppm or more)
Total Hydrocarbons:	0 to 5 ppm (with rare exceptions up to 75 ppm or more)
Stack Particulate Emissions:	
Units Without Control Devices:	60 to 900 mg/dscm (0.03 to 0.39 gr/dscf)
Units With Control Devices :	20 to 400 mg/dscm (0.01 to 0.17 gr/dscf)

zinc, arsenic, chromium, and others which are normally neither destroyed nor completely captured by the air pollution control device on the incinerator. In most cases the levels or concentrations of the metals in the feed were in the low ppm by weight range.

Additional information on EPA's testing program on industrial/commercial hazardous waste incineration is provided in Table 4 which shows the year the tests were performed, a brief description of the study, and brief information on the wastes involved in each of twelve (12) case stud-

TABLE 4

TWELVE MAJOR EPA SUPPORTED TESTS OF PILOT, FIELD, OR FULL-SCALE HAZARDOUS WASTE INCINERATORS (1974-1984)

CASE NO.	YEAR	STUDY	HAZARDOUS WASTE DESCRIPTION
1	1974	Incineration of DDT in a full-scale liquid injection unit	28 drums (55 gallons each) of DDT at 20% in oil
2	1974	Pilot 3-chamber incinerator adapted from classical early garbage burners	Nine (9) commercial liquid and solid pesticide formulations
3	1974	Vulcanus incinerator ship tests in Gulf of Mexico	Mixed Shell Chemical Co. high-chlorine organic chemicals
4	1975	Full-scale industrial incinerators	PVC plastic residues, organic solvents, etc.
5	1977	Vulcanus ship in South Pacific	Herbicide Orange stocks including TCDD
6	1981	Pilot-scale starved air (controlled-air) Los Alamos National Laboratory Incinerator	PCP-treated wood
7	1981	Full-scale Cincinnati MSD incinerator	Pesticide and high-chlorine liquids, HCB, HCPD, etc.
8	1981-1982	Vulcanus ship in Gulf of Mexico (2 burns)	PCB liquids, TCDF, chlorobenzenes
9	1983	Vulcanus II ship in North Sea	Mixed organochlorine volative compounds
10	1982-1983	Eight (8) typical field-scale commercial incinerators studied on regulatory impact analysis (RIA) program	Large variety of gaseous liquid, and solid hazardous materials
11	1982-1983	EPA's Edison, New Jersey mobile rotary kiln with afterburner facility	PCB, dioxins, chlorobenzenes
12	1983-1984	EPA's Combustion Research Facility pilot-scale rotary kiln with afterburner	HCB and 1,2-4 trichlorobenzenes in toluene

ies. For additional details, the reader may wish to obtain more detailed reports from the list of references provided herein.

The EPA has advanced to a state of "cautious optimism" about the effectiveness of high temperature incineration as a safe disposal practice for most organic compounds, based largely upon the case studies listed in Table 4. This is not to to say that EPA has ceased its research and development programs in this area, however. EPA is agressively pursuing a number of yet unanswered issues on incineration, the primary ones being:

- °As incinerator operating conditions (e.g., temperature, air supply, steady behavior or normal functioning systems, etc.) degrade, what are the impacts on overall environmental performance?
- °Which parameter (e.g., CO, temperature, residual hydrocarbons in emissions, etc.) may best serve as a real-time, effective measure of performance, in lieu of detailed, lengthy, and costly stack emissions analysis procedures?
- °Besides the currently measured emissions from the incinerator stack (e.g., small amounts of original compounds, small amounts of known products of incomplete combustion/recombination chemical species), what is the remaining amount of organic compounds in stack gas made up of?
- °What is the fate and transport mechanism for any inerts or inorganics (including metals and organo-metallics, etc.) should they be present in the feed in significant amounts?
- °Lastly, can even the most acutely toxic organic compound (e.g., dioxins, furans) be safely incinerated in low, medium, or high concentrations in the feed?

Regulatory Issues

Table 5 is a comparison of EPA's current regulatory requirements for incinerating hazardous wastes of the RCRA type, TSCA type, and for incinerating on ocean-going incineration ships. During the development of these regulations, the Agency based the various performance parameters primarily on the achievable performance experience noted for organic industrial wastes and to a lesser degree on organic pesticide formulation test results. Less pesticide incineration data is available than for other organics, although, the pesticide data that is on record indicates that except for the complicating issues of inorganics that are part of some cidies, organic pesticide compounds appear to thermally decompose about the same as their industrial counterparts. Regulatory requirements for pesticides are currently the same as for other RCRA or TSCA hazardous wastes. The issue of incinerating pesticides with metals or other complicating factors would probably be handled on a case-by-case basis, that is, EPA's permitting authorities (e.g., Regional Administrators and Headquarters personnel) would seek or require information on individual compounds or elements and their potential for release to the environment. Clearly, there may be a number of pesticides whose content of heavy metals, or halides such as bromine, for example, may preclude incineration unless either pretreatment steps can be developed or unless effective pollution controls on the incinerator can be demonstrated. Other purely organic types of pesticides (e.g., DDT, Silvex, 2,4,-D, chlordane, etc.) have already been allowed to be incinerated under current regulations.

ACKNOWLEDGEMENTS

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REFERENCES

1. Leighton, I.W., Feldman and J. B., Demonstration Test Burn Of DDT In General Electric's Liquid Injection Incinerator, USEPA Region I Report of 1974 (unpublished).
2. Ferguson, et al., Determination of Incinerator Operating Conditions Necessary for Safe Disposal of Pesticides, EPA-600/2-75-041, December 1975.

TABLE 5

COMPARISON OF REGULATORY REQUIREMENTS

	RCRA	TSCA	OCEAN INCINERATION (PROPOSED)
POHC DESTRUCTION AND REMOVAL EFFICIENCY (DRE)	99.99%	99.9999%	99.99% (99.9999% For PCB)
TEMPERATURE	Per Trial Burn	1200°C min. (PCB Liquids) Per Trial Burn (Non-liquid)	1100°C (Wall) min.
RESIDENCE TIME	Per Trial Burn	2 sec. min. (1200°C) 1.5 sec. min (1600°C) Non-liquid Per Trial Burn	1 sec. min.
COMBUSTION EFFICIENCY	None	99.9%	99.9%
STACK O_2	Per Trial Burn	3% min. (PCB Liquids) 2% min. (1600°C) Non-liquid Per Trial Burn	3% min.
HCl CONTROL	4 lbs./hr. max. or 99% Control	Per Regional Administrator	None
PARTICULATES	180 mg./dscm	Per Regional Administrator	None

3. Stretz, L. A., et al., Controlled Air Incineration Of Pentachlorophenol (PCP) Treated Wood, USEPA IAG No. AD-89-F-1-539-0, Draft Report.

4. Yezzi, J. J., et al., Results Of The Initial Trial Burn Of The EPA-ORD Mobile Incineration System, ASME 1984 National Waste Processing Conference, Proceedings, June 3-6, 1984, pages 514-534.

5. Ackerman, D. G., et al., Incineration Of Volatile Organic Compounds On The M/T Vulcanus II, TRW Energy and Environmental Division, April 1983.

6. Jackson, M. D., Ackerman, D. G., et al., At-Sea Incineration Of PCB-Containing Wastes Onboard The M/T Vulcanus I, EPA Contract 68-02-3174, EPA Report 600/7-83-024, April 1983.

7. D. G. Ackerman, et al., At-Sea Incineration of Herbicide Orange Onboard the M/T Vulcanus, EPA-600/2-78-036, April 1987.

8. Whitmore, F. C., Carnes, R. A., et al., Systems Reliability And Performance, PilotScale Incineration Of Chlorinated Benzenes At The USEPA Combustion Research Facility, EPA Contract

No. 68-03-3128, August 1984, Report In Publishing.

9. Trenholm, A., Oberacker, D. A., et al., Performance Evaluation Of Full-Scale Hazardous Waste Incinerators, Volumes 1-5, EPA Contract 68-02-3177, NTIS Nos. PB 85 129500, 129518, 129526, 129534, and 129542, November 1984.

10. Gorman, P. G., et al., Trial Burn Protocol Verification At A Hazardous Incinerator, EPA Contract No. 68-03-3014, NTIS PB84-159193, August 1984.

STORAGE, HANDLING AND SHIPMENT OF PESTICIDE WASTE-REGULATORY REQUIREMENTS

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This presentation will address the storage and transportation aspects of proper waste pesticide management under Federal law. Topics include the identification and classification of waste pesticides, notification requirements, the pre-transport requirements of storage, packaging, labeling, marking and placarding, the Uniform Hazardous Waste Manifest, recordkeeping, reporting and the farmer exemption. Under each topic, the waste pesticide generator's or transporter's requirements and the problems they may face in trying to comply with the regulations are discussed. Problem areas include waste determination, proper use of Department of Transportation nomenclature, compliance by small quantity generators, proper storage of waste pesticides, and compliance by commercial applicators.

Special focus is made on compliance with the new Uniform Manifest requirements and the impact of State laws on completion of this manifest.

Another area of focus is the RCRA reauthorization requirements for small quantity generators -- which includes waste pesticide generators.

National enforcement priorities and penalties are contained in the presentation. Although generators and transporters of hazardous waste account for the smallest percentage of EPA enforcement inspections, they represent a large national total. Additional enforcement inspections by other Federal agencies and state offices will augment the EPA program.

This presentation is aimed at pesticide users who generate or transport a hazardous waste and who must comply with Federal hazardous waste management standards. The purpose is to give these people a basic understanding of the regulatory requirements and enforcement ramifications.

WASTE PESTICIDE STORAGE AND TRANSPORTATION

I. REGULATORY BACKGROUND:

The Resource Conservation and Recovery Act (RCRA) was passed by Congress in 1976. The first set of regulations that the U.S. Environmental Protection Agency (EPA) promulgated appeared in the Federal Federal Register in February 1980. The major portion of the regulations, however, were promulgated in May of 1980. These regulations establish a series of standards including those for generators and transporters of hazardous waste. Many waste pesticides were identified as hazardous waste and therefore are regulated under RCRA.

II. GENERATOR/TRANSPORTER REQUIREMENTS

DETERMINATION

A generator's first obligation is to determine whether he has a hazardous waste. The generator may determine that his waste is excluded from regulation according to exemptions the Agency has established. One of the exemptions is for solid wastes which are returned to the soils as fertilizers. If a generator's waste is not exempted, a determination must be made that will classify and identify the waste he produces based on two general methods EPA developed. The easiest method is by finding the waste pesticide listed in the regulation. There are two ways that a waste can be listed. First, specific identification of waste pesticides are included (e.g., Aldrin and Dieldrin). The second which is a more generic method is one that identifies waste pesticides based on the means of production. For example, wastewater treatment sludge from toxaphene production. The other method requires more general effort on the part of the generator and involves a general classification method that includes the characteristics of waste pesticides. These classifications are defined by EPA as ignitable, reactive, corrosive and EP toxic.

Depending on the method of determination used by a waste pesticide generator, the level of compliance difficulty will vary. If it is necessary to test a waste to determine if it meets any of the characteristics, this may cause the greatest burden, including cost. A higher level of technical expertise will also be required for some waste determinations, and many waste pesticide generators may not posess this technical training.

GENERATOR REQUIREMENTS

- Waste Determination
- Notification
- Pre-Transport Requirements
  (including Accumulation Time)
- Manifest
- Recordkeeping/Reporting
- Special Conditions

EPA IDENTIFICATION NUMBER

Once a generator has determined that he is regulated under RCRA, he must notify EPA (or the authorized state in which he is located) that he is a generator, transporter, or owner or operator of a treatment, storage, or disposal facility, and obtain an EPA Identification Number. This notification number is required prior to offering hazardous waste for transportation, transporting, or treating, storing, or disposing of a hazardous waste. Application for an EPA ID Number may be made on EPA Form 8700-12.

This requirement is not likely to cause a high level of compliance difficulty. Also, since it is a one-time activity, the cost of compliance will be low.

UNIFORM HAZARDOUS WASTE MANIFEST

The Uniform Hazardous Waste Manifest (UHWM) is a new requirement which became effective September 20, 1984. The UHWM requires the use of a specific form for a manifest. Early requirements for the manifest did not include a specific form, but rather any form that contained certain information about a waste shipment. The UHWM manifest was developed as a result of an effort on EPA's part to minimize the burden of duplicative paperwork requirements placed on generators after several states developed their own manifest forms. Currently, the UHWM incorporates all the Federal information as a requirement of the manifest and provides a shaded area for optional information. Otherwise, generators would have been faced with the continued requirment to prepare several manifests for a single shipment of hazardous waste as a function of individual state requirements. By requiring the use of the UHWM, other state information requirements are preempted by Federal law as a condition of transportation. States may obtain the additional information they believe is necessary directly from the generator or from the treatment, storage, or disposal facility, but they may not detain a shipment of hazardous waste that is otherwise properly manifested for a minifest that does not contain information in the shaded area. The shaded area is, however, designed to allow the states to collect the information they believe is necessary without duplication of paperwork.

EPA has made it simplier for states that wish to obtain additional information to do so by requiring generators to acquire blank copies of the manifest from those states most likely to require additional information. EPA has developed a copy acquisition hierarchy that requires generators to get copies of the manifest first from the receiving (or consignment) state. Second, if the receiving state does not distribute copies of the UHWM, the generator must obtain copies from the state in which he is located (the generator state). If neither the receiving state nor the generator state distribute the UHWM, the generator may get copies of the manifest from any source.

This hiearchy was developed to provide the consignment state with the first opportunity to identify any additional information they believed necessary to run their hazardous waste management program since that state would have the ultimate responsibility for management of the waste. It should be noted, however, that where the receiving state and the generator state have duplicative or different information requirements for the shaded area, that the generator and the states involved must resolve any potential problems that result.

Management and tracking of the manifest includes signatures by the generator, each transporter and the owner or operator of the designated facility. If the generator has not received a signed copy of the manifest back from the facility within 45 days he is obligated to submit an Exception Report to the Regional Administrator. (See a more complete discussion of Exception Reports under "Reporting", below.)

Compliance with the manifest system is likely to be the most important aspect of the generator's responsiblities. Since the UHWM is the transportation safety and tracking document that serves as proof of proper management of a waste shipment, cradle to grave, generators should take special care to ensure that it is handled properly. Generators should take care to properly identify their waste shipment on the manifest and establish a good internal tracking system to help ensure timely follow-up.

PRE-TRANSPORT

The next requirement for generators is the compliance with pre-transport requirements which include standards for packaging, labeling, marking, placarding and accumulation time (or temporary storage). Since most of these standards are related directly to transportation, EPA chose to reference the existing Department of Transportation (DOT) requirements in most cases. Specifically, the DOT requirements for packaging, labeling, marking and placarding are adopted by EPA for hazardous waste generator pre-transport requirements. In addition to the DOT standards, EPA established new marking requirements and requirements for accumulation of hazardous wastes prior to treatment, storage, or disposal. The EPA marking requirements require the generator to mark each container of 110 gallons or less with a specific statement:

HAZARDOUS WASTE: Federal Law Prohibits Improper Disposal. If found, contact the nearest police or public safety authority or the U.S. Environmental Protection Agency.
Generator's Name and Address__________
Manifest Document Number____________

The accumulation time provision allows generators up to 90 days to hold a hazardous waste without obtaining a permit for storage, provided they meet certain requirements. These standards include the use of tanks or DOT containers and compliance with certain requirements for owners and operators of treatment, storage, or disposal facilities (including container and tank management requirements and certain prevention and contingency/emergency requirements). In addition, each container must be marked with the words "HAZARDOUS WASTE" and the date upon which accumulation began.

Although most of the pre-transport requirements reference existing DOT standards, there may be some initial compliance difficulties for waste pesticide generators not familiar with those standards. The accumulation time provision may cause additional compliance problems particularly for those waste pesticide generators who are sometimes small quantity genrators. Close scrutiny of waste management practices will, however, help alleviate most of these problems. Many waste pesticide generators may find it beneficial to utilize the services of specialized transporters experienced in farm waste or small quantity generator waste management.

PRE-TRANSPORT REQUIREMENTS

	DOT	EPA
• Packaging	X	
• Labeling	X	
• Marking	X	X
• Placarding	X	
• Accumulation Time		X

NOTE: Changes in the accumulation time and small quantity generator requirements are being made as a result of recent Congressional changes to RCRA. See Section III, RCRA Reauthorization, below.

RECORDKEEPING/REPORTING

Recordkeeping:

The recordkeeping practices required of generators under RCRA are in keeping with most good business recordkeeping practices. Copies of documents such as manifests, Biennial Reports and Exception Reports are required to be kept for at least three years. Similarly, copies of test results, waste analyses, or other assessments made as a result of determining whether a generator is regulated must be kept for at least three years from when the waste was sent for on-site or off-site treatment, storage, or disposal.

The periods of retention (at least three years) are extended automatically during the course of any unresolved enforcement action regarding the regulated activity or as requested by EPA.

Reporting:

Generators who ship hazardous waste off-site must submit a single copy of a Biennial Report to the Regional Administrator by March 1st of each even numbered year and the report must cover information gathered during the previous calendar year. These reports contain some administrative information plus descriptions of the wastes managed including the amounts shipped off-site.

Exception Reports must be file by the generator for every manifest not signed by the owner or operator of the designated facility and returned within 45 days from the date of shipment. The Exception Report contains a legible copy of the manifest and a letter that explains the generator's effort to locate the hazardous waste and the results of those efforts.

Additional reporting may also be required by EPA.

Compliance with the recordkeeping and reporting requirements is not expected to be difficult. No special technical or costly management practices will be involved in complying with the recordkeeping or reporting requirements.

SPECIAL CONDITIONS:

The generator standards contain two special conditions. One, international shipments, is not likely to effect waste pesticide generators as much as the other, the farmer exemption.

The farmer exemption allows a farmer disposing of waste pesticides from his own use to do so on his own property if he complies with the disposal instructions on the label and triple rinses the pesticide container.

For many farmers, this provision will allow them to manage their hazardous waste pesticides without substantial burden of regulation under RCRA. The good pesticide management practices of mix control, application sequencing and rinse water reuse will also help minimize the generation of hazardous waste pesticides. Extension to the time a generator may hold his hazardous waste without needing a permit will soon be extended from 90 days to 180 days for small quantity generators (SQGs) and 270 days for SQGs who ship thier waste over 200 miles (see Section III, RCRA Reauthorization, below). Other generators will still have 90 days to accumulate up to 1000kg of hazardous waste prior to treatment, storage, or disposal. These accumulation times will allow generators, and especially farmers, sufficient time to prepare economically feasible quantities for shipment off-site.

III. RCRA REAUTHORIZATION

Small Quantity Generators (SQGs)

Congress reauthorized RCRA at the end of 1984. Part of that reauthorization requires the Agency to develop standards for small quantity generators that lower the exemption level from 1000 kilograms per month (kg/mo) to 100 kg/mo. The effect that this will have is to increase the number of generators from approximately 55,000 to about 175,000. Waste pesticide generators are among the top ten newly regulated generators.

Some relief, however, is provide to SQGs. Since, by definition, SQG will be producing small quantities of hazardous waste, the amount of waste they will accumulate in a 90-day period is also likely to be very small and uneconomical to ship off-site. Congress, therefore, has allowed for an extension of the 90 day accumulation time provision. The new requirement will allow for 180 days or 270 days if the waste will be shipped to a treatment, storage, or disposal facility over 200 miles away. In addition, SQGs will be allowed a maximum of 6000 kilograms of accumulation rather than the 1000 kg limit for other generators.

There may also be some relief for SQGs effective August 1985. The reauthorization provisions establish a minimum manifest. This provision would reduce some of the information requirements but this reduction in information is not considered by some to be a significant savings.

Compliance difficulties for waste pesticide generators is not likely to be any more difficult than for other waste generators with the exception that many farmers, together with all small quantity generators, will not be familiar with federal hazardous waste management rules. The EPA is examining the possibility of an education program aimed at SQS's, and therefore farmers, the purpose of which would be to explain the requirements of the new regulation. It is expected that specific industry categories, will be targeted for special attention (e.g., farmers, automotive services, metal finishers, photography). Once the learning process has been achieved, compliance with the lower exemption levels is not expected to be difficult.

IV. ENFORCEMENT STRATEGY

EPA has developed an enforcement strategy that helps us to manage our resources effectively and to promote an aggressive enforcement program. The result is a strategy that calls for inspections of all major hazardous waste handlers (including 3% of all generators and transporters), 25% of all non-major hazardous waste treatment, storage, or disposal facilities, 7% of non-major generators and transporters, and 100% of closed treatment, storage, or disposal facilities.

> Major hazardous waste handlers include: 100% of facilities subject to ground-water monitoring, all incinerators, 10% of remaining treatment, storage, or disposal facilities and 3% of generators and transporters.

Although 3% of major generators and transporters and 7% of non-major generators and transporters is not a large percentage, the number of inspections is relatively large. There are several other factors that increase the number of inspections that are likely to occur against generators of hazardous waste. Some of the major and non-major handlers that will be inspected will also be generators.

States that are authorized to run the hazardous waste program will be required to have an inspection strategy similar to EPA's. They will, however, be allowed to have a more stringent program and as a result, may have a more stringent inspection program. Further checks on compliance will be conducted as a matter of routine inspections conducted by other Federal agencies, in particular, the U.S. Department of Transportation.

V. PENALTY POLICY

The RCRA administrative penalty policy establishes a procedure by which administrative penalties can be calculated in a fair and consistent manner. It is designed in such a way that penalty amounts should reflect the gravity of the violations and eliminate any economic benefit gained through non-compliance.

The penalty amount is initially determined by consulting a 3x3 matrix which considers on one axis the potential for harm resulting from the violation and on the other axis, the degree to which the violator deviated from the regulatory requirement. The basic penalty amount can then be adjusted on the basis of several additional factors, including:

- °economic benefit derived from non-compliance
- °good faith efforts to comply
- °degree of willfullness and/or negligence
- °history of noncompliance
- °ability to pay (downward adjustment only)
- °other factors.

Further, the basic penalty can be considered a per-day penalty and can be multipled by the number of days of non-compliance, if the Agency so chooses.

TABLE I

PENALTY POLICY MATRIX

Extent of Deviation from Requirement

Potential for Harm	Major	Moderate	Minor
Major	$25,000 to $20,000	$19,999 to $15,000	$14,999 to $11,000
Moderate	$10,999 to $ 8,000	$ 7,999 to $ 5,000	$ 4,999 to $ 3,000
Minor	$2,999 to $1,500	$ 1,499 to $ 500	$ 499 to $ 100

ALL PENALTY AMOUNTS ARE PER DAY VIOLATIONS

The administrative penalty policy was developed for EPA use. It was in no way intended that the States would be required to follow the policy, although they are welcome to do so if they choose. It should be noted that the penalty amounts suggested in the matrix are based on the maximum penalty authorized by RCRA - $25,000/day/violation. State statues may or may not authorize the assessment of similar amounts of penalties.

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NOTE: The RCRA/Superfund Hot Line is available to answer any questions you have regarding this or any other RCRA topic. [(800) 424-9346 -- In Washington, D.C. call 382-3000].

ALSO NOTE: The EPA Small Business Ombudsman is also available at (800)368-5888 to assist small business faced with compliance with EPA regulations.

THE LOGISTICS OF TRANSPORTING PESTICIDE WASTES FROM THE USER TO DISPOSER

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ABSTRACT

The new RCRA reauthorization act will require that most pesticide wastes be disposed of in a RCRA approved incinerator, and it will also increase the number of generators of pesticide wastes that will be subject to RCRA regulations.

There are only five major commercial incinerators in the United States that can incinerate pesticide wastes, which means that the wastes will have to be transported long distances for disposal. To economically accommodate the logistics of picking up small quantities of wastes and transporting them long distances, transfer stations are needed throughout the pesticide use areas. At these transfer stations, small quantities of wastes would be consolidated and shipped by tractor trailers or rail cars to the disposal facility.

The paper covers the operation of the transfer station, the type of company that would likely operate the station, and the transportation requirements from the generator of the pesticide wastes to the transfer station and then to the disposer.

DISCUSSION

"The Hazardous and Solid Waste Amendments of 1984" - The Resource Conservation and Recovery Act (RCRA) reauthorization will have far reaching effects on those involved with pesticides. The three major effects of this legislation and the resulting regulations on the user of the pesticide, who is the generator of the pesticide wastes, the transporter of the wastes, and the disposer of the wastes are:

- Many more generators will be covered by RCRA regulations because of the generator definition being changed from those who produce less than 2,200 pounds of waste per month to those who produce less than 220 pounds per month.
- Additional types of pesticide wastes will be regulated by RCRA.
- Restrictions on the treatment/disposal processes used to handle pesticide wastes.

This means there will be greater volumes of pesticide wastes to manage under the new RCRA standards and that there will be fewer treatment/disposal facilities available that can meet the new treatment/disposal criteria. This in turn means that wastes will probably have to be shipped greater distances for treatment/disposal. The costs for managing these wastes will obviously increase because of the more costly treatment/disposal requirements along with longer shipping routes.

A higher percentage of the organic pesticide wastes and the solvents used to flush empty contaminated containers will probably have to be incinerated because of the forthcoming RCRA regulations. There are presently only a few such incinerators available, and with the present siting problems, there is a very slim chance that major new incinerator capacity will come on stream in the near future. This will generally mean longer hauls between the generators and the disposer's sites.

If all the generators had full 42,000 pound truckload quantities of wastes, the transportation problems would easily be solved. However, with a number of small generators, and with a large part of the waste problem being the disposal of contaminated empty containers, new solutions have to be forthcoming.

Transfer station networks have to be established to accommodate the small generator's wastes, so as to most cost effectively clean and return the containers to commerce, and to prepare the wastes for bulk shipment to the disposer. There is no such major network presently operating in the United States. There is a government sponsored container collection program in operation in Alberta, Canada that is described in James L. McKinley's paper, "The Pesticide Container Collection Program of Alberta, Canada". To fill this void in the United States, a transfer network could be established by:

- Distributor of the Pesticide
- Manufacturer of the Pesticide
- Local Hauling Company
- Disposal Company
- Government

What would be the transfer station and transportation needs? One scenario is a pesticide distributor and a major transporter/disposal company working together to solve the generator's pesticide waste problems.

The empty, contaminated pesticide containers would be picked up at the generator's site by the same truck that the distributor used to haul the full containers. This truck would have to be properly placarded and, depending on the forthcoming small generator regulations, may also have to have a hazardous waste manifest.

As an option to this, the generator could transport his own containers directly to the transfer station. Again, appropriate truck placarding and manifesting would have to be followed. In actual practice, both of these options would probably happen. The local transfer station could be part of the distributor new product warehouse. When a full truckload of containers were collected at the local transfer station, the containers would be sent to a regional process/transfer station. At these stations the metal and plastic containers would be separated and the smaller than 55 gallon shredded.

The shredded metal and plastic would be solvent washed. One appropriate approach would be to utilize a Freon cleaning system. This system would include a Freon distillation column so that the Freon and pesticide wastes can be separated, with the Freon being reused and the pesticide waste isolated for transportation to a treatment/disposal site. This system would reduce the costs of the solvent used, and also reduce the amount of contaminated solvent that would have to be disposed. If the pesticide was water soluble, a triple rinsing with water would take the place of the solvent cleaning.

The cleaned metal and plastic can be sold into the reclaim market, or if no market exists, sent to a local sanitary landfill. The pesticide wastes can be containerized in 55 gallon steel drums, or if the quantity dictates, pumped into holding tanks.

Since this facility would be processing and storing RCRA controlled wastes, it would have to have a RCRA permit, and be in compliance with the appropriate RCRA regulations. Unless the regulatory agencies can simplify the permitting procedures, this permitting aspect of this operation could be a major problem, and one that could cause long time delays in implementing these plans.

The transportation between the transfer site and the treatment/disposal facility would be by box tractor trailer if the wastes were in drums, or if in bulk a 5,000 gallon tractor tank trailer or a 20,000 gallon rail tank car. For most pesticide wastes, carbon steel would be the material of construction required for these tankers. If water was used as the wash medium, it would have to be collected and analyzed for the degree of contamination. The disposal of the contaminated water would depend on the amount and type of pollutants present. The disposal options would range from discharge to local sewer to incineration.

The waste shipments would require a waste manifest, with the transfer facility being considered the generator. The transportation costs for shipping truckloads of hazardous wastes are about $2.75 to $3.00 per loaded mile and rail shipments about $1.00 per loaded mile.

High temperature incineration would probably be required for the disposal of the pesticide waste mixture. If this is the case, the wastes would be transported to the incinerator facility, and before the material was offloaded from the transport vehicle it would be sampled, analyzed, and a decision made on what storage tank it can be pumped to and what incineration conditions are needed to incinerate it. The waste is pumped from the storage tank to a blend tank, where it is mixed with other wastes to achieve a blend for optimum burning. The incineration would take place at temperatures above 2000°F with destruction efficiencies of greater than 99.99%.

Based on ballpark economics, it is felt that a 5 gallon container could be handled through this system, including cleaning, transportation and disposal of the residues for under $5.00 per container.

Although this price may seem high in comparison with present disposal costs, the RCRA regulations are going to dictate more stringent requirements for the management of our pesticide wastes, which are all going to cost additional money.

CONCLUSION

The scenario presented is a practical, cost effective approach. The greatest hurdle in putting this plan into action is not attracting private enterprise to participate, but obtaining the cooperation from the regulatory agencies in obtaining the necessary permits and approvals.

EMPTY PESTICIDE CONTAINER MANAGEMENT
AN OVERVIEW

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ABSTRACT

There are three basic options for managing empty pesticide containers including return for reuse, recycling, and disposal by burning or burial in approved facilities. Each is surrounded with economic, environmental, and institutional barriers, and are not widely practiced; containers continue to pile up in uncontrolled sites which evoke citizen complaints and provide a basis for regulatory action. Open burning and burial in fields is no longer legal under environmental legislation, and applicators are starting to express concerns regarding their options. A major institutional barrier is the EPA definition of empty, which varies depending on which hazardous waste list the pesticide is on; amendments cause confusion over whether a container must be triple rinsed, and the provision for an inch of residue in some containers worries landfill operators.

Recycling currently is the best available option, but substantial research work on plastic containers is urgently needed. Plastic compounds used need to be identified, and the behavior of pesticides at the temperatures used in plastic reforming needs to be described. Similarly, operators of resource recovery/trash-to-energy facilities require data on products of combustion of pesticide containers and residues.

Overall, a major communication crisis exists between the pesticide community and the waste management community. Concerted efforts must be made by those who make, sell, use, and regulate pesticides to learn how to convince waste handlers and their regulators that 'empty' containers are not hazardous wastes. Development of programs to promote proper rinsing will help, but an on-site verification procedure also is necessary. Failure to address this situation now will increase the broadly-based pressure that already exists to legislatively mandate the return of containers to the manufacturers for reuse.

INTRODUCTION

At the National Conference on Pesticide Containers in 1972 a number of problem areas were identified. These related to : a convenient means to decontaminate containers; reduction of the hazard of pesticide exposure to landfill workers; disposal of containers at airstrips; need for more information by States to regulate containers; and the urgent need for better communication between industry, government, and the public. Not much has been done to resolve these problems, and the same concerns are expressed by the same people today.

In 1978 many of these same problems were repeated at EPA's Pesticide Disposal Research Symposium. In addition, a plea was made for the development of inexpensive, simple, low-technology methods that could be used by farmers and commercial applicators. It also was suggested at that forum that an examination of the impact of all Federal rules on pesticide container disposal be made, and that research into ways of communicating with the public regarding pesticides and containers be undertaken. There is no evidence that any of these concern have been resolved, or that serious study is underway. We still do not have any simple 'water bucket' chemistry methods for decontamination, or soil column filtration and land disposal techniques. Organized programs to promote proper rinsing do not seem to exist, and there appears to be little or no sentiment on the part of industry to cooperate. No moves have been made to improve communications, on a national level, with the waste management industry, and the need for addressing citizens' concerns seems to have been forgotten.

AVAILABLE OPTIONS

There are only three basic and feasible options for dealing with the management of 'empty' containers. These are return for reuse or refilling, recycle to the scrap stream of for energy recovery, and disposal by burial or burning in approved facilities. Each has its own set of economic, environmental, and institutional problems which must be dealt with before being put into practice. Disposal by open burning or burial in the field is not viable, long term, because of prohibitions in the many environmental laws that have been adopted to help prevent further environmental insult.

A first step in using any of the feasible options is to make sure the container is empty. According to EPA rules, an empty container is not a hazardous waste, and thus can be handled or disposed of in a facility that does not need a hazardous waste permit. These rules, which provide the basic guidance for many States, are, however, confusing. As shown in the table (Table 1.), a pesticide container may need to be triple rinsed, or it may contain an inch of residue and still be classified as empty, depending on which hazardous waste list the pesticide is on. Note that these were the rules, as far as could be determined, in the fall of 1984. Continuing amendments to the EPA hazardous waste regulations tend to change the type of waste that is assigned to each pesticide, and the impact of new requirements in the amendments to the Resource Conservation and Recovery Act (RCRA) have yet to be felt. EPA could make a major contribution to dealing with this institutional barrier by issuing interpretations on a timely basis that can be readily understood by both the pesticide community and by those who must handle and regulate the disposal of municipal wastes.

TABLE 1. EPA EMPTY CONTAINER RULES*

Type of Waste	Size of Container 110 gal.	 110 gal.
Acute Hazard.	Tr. Rinse	Tr. Rinse
Toxic Hazard.	1 inch or 3% wt./vol residue	0.3% wt/vol residue

*Basis: 40CFR261.7, 1984.

HOW CLEAN IS CLEAN ?

In a practical sense, it seems apparent that all containers must be triple rinsed, since continuing changes in the EPA hazardous waste lists categories may change the existing rules. But another, and perhaps more important, reason is to help convince waste managers that it is safe for them to accept empty containers. Even with the best procedures, some small residues may remain, as shown in Table 2. These

TABLE 2. TRIPLE RINSE CALCULATIONS*

Stage	Residue Liquid	 Pesticide
Drained	1 oz.	14.1875g.
Rinse/Drain 1.	1 oz.	0.2183g.
Rinse/Drain 2.	1 oz.	0.0034g.
Rinse/Drain 3.	1 oz.	0.00005g.

*Basis 4 lb/gal,5 gal.,10% of vol.

theoretical, calculated data are based on rinsing a 5 gallon metal container which formerly contained a 4 lb. per gallon formulation with solvent equivalent to 10% of the capacity of the container (2 qt.). Assuming full 'solution' at each rinse step, and draining until no more than 1 oz. remains, there will still be some residues left. While residues from a single container may seem insignificant, quantities may become measurable when a larger number is involved, as shown in Table 3.

TABLE 3. IMPACT OF THREE RINSES

Stage	Pesticide left in 25,000 containers
After draining	780 lb.
After 1st rinse	12 lb.
After 2nd rinse	0.2 lb.
After 3rd rinse	0.003 lb.

It becomes very clear, then, that we need to triple rinse in order to remove these residues from containers, and put them in the spray tank where they belong.

THE RE-USE OPTION

Manufacturers have long considered taking containers back and re-using them, but except for a few specialized cases, have rejected the option out of hand. Reasons given are costs (new containers have been cheap,comparatively), DOT regulation of certain types, and the potential for cross contamination in the event of another pesticide being put into a labeled container. However, this option needs to be rethought, after some serious study of these problem areas. Calls for legislation to mandate reuse were heard many times during development of container regulations in Maine, and not only from environmentalists and regulators; dealers and users also think it's a good idea. A re-evaluation of all the factors involved could provide data for use in development of programs to forestall the passage of precipitous laws that might be difficult to live with.

RECYCLING OPTIONS

Recycling metal, glass, and plastic containers into the scrap stream remains the best and most reasonable option. The small residues of pesticides are totally consumed by heats of upwards of 2000°F. used in melting steel and glass. Unfortunately, not all of the containers sent for recycle have been properly rinsed, and the scrap handlers have, in some cases, refused to accept them. A means of verification that containers really have been triple rinsed, one that can be demonstrated on the spot and for each container if necessary, may be the only solution to this problem area. Managers of recycle operations must be convinced that only clean containers will be delivered, and assured that the sins of the past won't be repeated.

Plastic recycling is a whole different matter. Lower temperatures used in molding are not high enough to destroy pesticide residues but may be sufficient to cause the generation of fumes. Plastic recyclers are reluctant to accept containers when there is a lack of knowledge concerning the potential compounds they may encounter. Yet, manufacturers continue to adjust the mix of resins and plasticizers used in containers for specific pesticides and formulations. There also is genuine concern that the relatively porous walls of plastic containers may retain some of the pesticide; as one person described it, "those pesticide-soaked jugs."

These problems should be studied to facilitate plastic recycle. Many products, such as sewer pipe, soil drainage tubing, agricultural mulch film and others offering sizeable markets may be appropriate uses for this scrap. And there aren't many institutional problems here, since environmentalists and regulators by and large support the concept and will work to facilitate it.

RESOURCE RECOVERY

Recycling containers via resource recovery plants means converting combustible containers into energy, usually with high temperature incinerators. Modern units generally can reach the temperature levels needed to destroy all the fumes from pesticides, but many are not operated at such levels continuously. Operators need to know ahead of time what the burning characteristics are for each pesticide, and they also need to be aware of the potential for harmful stack gases, such as chlorine, sulfur, bromine, fluorine and the like. A major concern is the amount of dry material (powder,dust,etc.) that may cling to bags, boxes, and fiberboard drums, as well as liquid pesticides that may have soaked into the walls of plastic jugs.

Generally speaking, operators of resource recovery plants will accept empty pesticide containers if asked. However, they also want to know more information about the burning profiles of pesticides than is generally available. Thus, some advance planning and establishment of good communications are absolutely necessary if this option is to be viable. Unfortunately, as EPA noted at this workshop, data on incineration of most pesticides are not available at this point in time.

There is an urgency to develop the necessary data and information. Increasing concerns about the impact of landfill leachate on groundwater have led the waste community to favor disposal of all combustibles in such resource recovery plants. The time may come when landfills will be off limits to all but inert wastes.

DISPOSAL

Final disposition of those containers that could not be reused or recycled traditionally has been in landfills or out on the back forty. Sometimes these were buried properly, sometimes improperly, and sometimes not at all. It's the last method that has caused so much concern and stimulated passage of laws to control disposal.

Burial in the field where the pesticide was used has long been recommended by manufacturers and agriculturists. Many container labels still have such recommendations. The amended RCRA, however, precludes this option, since it mandates that disposal of any waste in a non-approved site be called 'open dumping', which is prohibited.

Similarly, open burning of pesticide containers is prohibited by Federal and most State laws. The concerns center around the lack of knowledege concerning unburned or partially burned containers and residues. Often compounds more toxic than the parent pesticides are generated around the edges of open and uncontrolled burning sites. Until these can be identified and their toxicities described, it's likely that open burning will continue to be banned most everywhere.

LANDFILLS

Pesticide containers that have been triple rinsed or equivalent are classified as non-hazardous by Federal rules on hazardous waste. While many States use these as a basis for their own regulations, not all agree with the classification. As a result, some States classify triple rinsed pesticide containers as 'special waste', and require any landfill wishing to dispose of them to obtain a special permit. In at least some cases, this is the only excuse needed to prohibit disposal of pesticide containers, especially in areas where there have been prior concerns about pesticides.

In a larger sense, landfill operators have major concerns over how well containers were rinsed and how well they were drained. The importance of good draining after each rinse step can easily be seen in the calculated residues shown in Table 4. The residues remaining when all except 1 ounce was drained were shown earlier. These data reveal that while linear increases can be expected after the first drain step, residues higher than this can be expected after the rinse/drain steps. Thus, it becomes extremely important to drain containers as completely as possible at each stage in the triple rinse procedure. It also becomes apparent that containers should be punctured to facilitate good drainage as well as to prevent unauthorized reuse.

TABLE 4. IMPORTANCE OF DRAINING

	Liquid residues	
Stage	2 oz.	3 oz.
	(lb. pesticide)*	
After draining	1560	2340
After 1st rinse	47	105
After 2nd rinse	1.4	4.7
After 3rd rinse	0.04	0.2

* 25,000 containers

Even if well rinsed and drained containers, with verification, are delivered to landfills, operators may be reluctant to take them for another reason. Landfills are expensive; capital costs in the Northeast range from $15,000-25,000 per acre for unlined sites, and from $70,000-85,000 per acre for sites where linings are necessary. A site to handle the wastes for 20 years from a community of 5,000-8,000 will require 30-40 acres. Officials who must raise the funds and fight for site approvals aren't exactly happy when approached with demands to take a waste that not only will help fill up the landfill faster, but may be the cause of problems in the future if some of the containers were not properly rinsed and drained. Again, an urgent need for communications.

THOUGHTS AND SUGGESTIONS

The pesticide community needs to start paying serious attention to this problem. Research in the past has focused on degradation and disposal of pesticides, but little has been done on containers. A place to start is the development of a test that can be used on-site to verify that containers have been properly rinsed. A start on such a quick test has been made in Maine for a limited number of compounds; it should be expanded to be useful on the national scene.

Work also is needed on how to deal with dried-on residues. Many applicators plead that there is not enough time during their busy hours to properly rinse containers as they are emptied. Yet, there are no practical methods to remove the residues that dry out before rinsing. Landfill operators fear that the "garbage juice" found in their sites may be strong enough to dissolve these residues and result in contamination of their liquids. Even if they are wrong, work to show what does happen is needed.

The pesticide community also must learn how to communicate effectively with the waste community and the public on this matter. We must learn how to convince everyone that we are a responsible group and that we really are cleaning up our act. We need to achieve credibility in order to do this, and perhaps a good start would be to initiate some highly visible training programs to promote better rinsing of containers. These need to be well planned, and involve all of the pesticide community - manufacturers, dealers, and distributors as well as users, regulators, and educators. If the public can see for itself that real efforts are being made, then perhaps some of the hysteria can be dealt with in a rational manner. Media cooperation in such programs is absolutely necessary; they are often uncritical in their treatment of the so-called deadly chemicals, and pesticide containers seem to fall into that category, whether rinsed or not.

Another suggestion is to develop some creative enforcement policies and ideas to replace the confrontational programs of the past. Regulation of the disposal of pesticides and containers cuts across several programs at both the Federal and State levels. These programs need to be coordinated so that new ideas and plans put into effect by one agency won't be shot down by another. Conversely, programs clearly at odds with existing rules should never be allowed to surface.

SOME QUESTIONS

One question that has bothered me for a long time is "Why does everyone except those in the pesticide community get so emotional whenever the word 'pesticide' is mentioned ?" Do all those people think that we are irresponsible and out to poison them and the environment ? What brought us to this situation ? More importantly, what can we do about it now ? Is it our desting to always be on the defensive, and scorned by the public in general ?

Are people skeptical about our intentions because no truly demanding training courses or programs are required for those who use the most toxic pesticides ? Would it be an improvement if dealers and distributors - locally perceived as the real experts - established some tough standards for training their own workers, and publicized this ? And then assisted in training others ? What should the roles be for dealers and distributors in disposal ? Would their credibility be improved if they were in the inspection and verification chain to assure that containers are properly rinsed ?

A LAST THOUGHT

In an overall sense, we cannot have practical and successful empty container management programs unless we have the full cooperation of the waste management industry, including the regulators. Whether we elect to send empty containers to the scrap stream, recycle them for energy, or dispose of them by burning or burial in approved facilities, we can do it only with appropriate permission and oversight. A first step, then, must be to establish good lines of communications; only then can we learn how to speak their language, and work to improve our credibility. It must be said that we need them, but they don't need us.

ALBERTA PESTICIDE CONTAINER COLLECTION PROGRAM

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ABSTRACT

The lack of convenient disposal facilities for empty pesticide containers prompted the Alberta Government to initiate a province wide container collection and disposal system.

The use of pesticides has become a very integral part of agriculture. Farmers have become very dependent upon the use of chemicals to maximize their annual crop production. This chemical dependency has promoted a dramatic increase in the number and type of pesticides available for use. Due to the increase in pesticide use and the potential hazards associated with pesticides, the safe disposal of the empty pesticide containers has become important. Despite potential hazards, the undertaking of safe disposal methods has not been followed by many users of commercial pesticides. Often, empty containers have been discarded as conveniently as possible. The containers have not been rinsed, punctured or crushed as recommended. Most empty containers have been mixed with various forms of garbage and deposited in unapproved landfill sites. Empty pesticide containers have also been dumped in out-of-the-way, seemingly unimportant areas. Such areas have included coulees, river banks, creeks, roadside ditches or various corners of private land. Some of the containers that were not discarded are being re-used for such purposes as carrying feed or water. Unfortunately, public awareness of recommended safety precautions and proper disposal methods associated with pesticide chemicals has not kept pace with the expanding chemical industry. Some pesticide users seem to be either ignorant or unconcerned of the consequences of their actions. They do not realize that by following the convenient method of disposal, they have created hazards for both themselves and their environment. To complicate matters, approved disposal sites that are equipped to deal with the disposal of empty pesticide containers are too few in number. Pesticide users often had to travel a far distance to dispose of their containers at these approved sites. For most users, the inconvenience and time involved to deliver the containers discouraged them from following recommended disposal procedures.

The continued use of unsafe disposal methods has produced a situation of concern to many officials. The lack of public awareness and disposal alternatives have contributed to the growth of extensive public and environmental hazards. A regular program involving public information and the establishment of safe disposal methods will help to alleviate and eventually eliminate these hazards. In order for such a program to be effective, the public must be convinced that the disposal alternatives offered can be equally or more convenient than their present methods. The program must also inform the public of the hazards they may be faced with and the importance of following the acceptable forms of container disposal. The success of such a program will require the co-operation of all individuals concerned; chemical manufacturers, governmental and local authorities and the general public.

The pesticide container collection program in Alberta has attempted to address these problems with a cooperative program which has not relied on legislation to meet its objectives.

The program began in the summer of 1979 when large numbers of pesticide containers were found in water bodies in southern Alberta. It was decided at that time to remove and dispose of these containers. The containers that were removed were temporarily stored at Environment property with the idea to crush and landfill them at a later date. However, farmers in the area noticed what was happening and began bringing containers to the storage area. The result was instead of having 300 containers we now had 5000 and the beginnings of a container collection program.

Since that time the program has been expanded to 78 permanent collection sites and a yearly collection of over 500,000 containers. These sites are built to our specifications by the local municipality using a grant provided by the provincial government. Each spring a contractor is hired to remove the containers and residues for recycling and/or disposal. We have been attempting to recycle this material as much as possible although the main purpose of the program is to keep the containers and residues from contaminating the environment.

Pesticide containers are constructed of metal, plastic or paper. The paper containers (bags) are relatively easy to handle and are either burned or landfilled. The metal containers are recycleable if handled properly. We have tried numerous handling methods however, the most cost effective and simplest is the one we use. The container is crushed with a simple hydraulic crusher and transported to a scrap metal dealer. There the crushed containers are stored until they can be inserted into scrap car bodies which are then recycled at a local steel mill.

When the program began the number of plastic containers collected was less than 10 percent of the total. That number has been climbing steadily and this year, 1984, for the first time plastic containers will exceed 50% of the total. The recycling and/or disposal of this plastic is much more difficult than the metal. Our tests have shown that chemical residues are completely broken down at the high temperatures used to melt the metal. However, we have no burning system available for plastics and the pesticide industry has informed us that they expect to be 90% converted to plastic by 1990. The material used in plastic pesticide containers is a high impact polyethylene which has many uses as recycled material. However, the problem is that in order to utilize the plastic the pesticide residues must be removed and this requires that the containers be shredded and washed. This is not an inexpensive process as we found out in 1983 when we cleaned 180,000 containers at a cost of $90,000. This is not a cost effective process and a method must be found to reduce the cost before we can begin recycling plastic containers again. In the interim we are now storing the containers in a shredded form while we search for an economical recycling method.

The program is a cooperative one between the pesticide user, local municipality and the provincial government. The provincial government provide the funding and administration, the local municipality provides a collection point and the pesticide user provides the empty containers. This system has worked exceptionally well and we estimate that 68% of all commercial pesticide containers sold in Alberta are voluntarily returned to a collection site for disposal.

MAINE'S RETURNABLE PESTICIDES CONTAINER PROGRAM

by

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The State of Maine is in the process of developing a program for the management of all hard plastic, metal and glass restricted use and limited use pesticide containers. The scope of this program is not extremely large. It is true that the Maine restricted use list is somewhat larger than the federal list. The limited use pesticides, however, are those that have shown unusual propensity to cause environmental or human damage due to chronic exposure. Limited use pesticides are, in effect, a kind of "super restricted use" granted only in circumstances where there are no viable alternatives. At the present time only two limited use pesticides are in use in the state.

In 1981 one of our inspectors reported to me that he felt the pesticides containers were being improperly managed, particularly in the northern portions of the state, comprising Aroostook and Penobscot Counties. Attention to open dumping, visible from the roads, resulted in an enforcement action that year plus several instances of compliance and clean up. However, it was not until we began aerial surveillance of right-of-ways, looking for herbicide damage and improper application in the fall of 1981 when midway through the program, we discovered that we had found no herbicide damage but had uncovered 14 pesticide container dumps in or adjacent to the utility and railroad right-of-ways. We shifted our emphasis in midstream and have continued a similar type of program every year since, resulting in the identification of over 400 illegal and open pesticide container dumps in our state.

The cleaning up of pesticide containers by burying them in the ground is only a partial solution of the problem. For one thing, it is difficult if not impossible to monitor on-farm burial sites to determine if containers have been adequately triple rinsed and properly crushed and buried. The opportunity for abuse and burial of actual pesticide material is quite great and the probability of enforcement activity resulting in prosecution is quite low. Another avenue of container disposal for plastics has been open burning of these materials. Both the burying on the farm and the open burning in the field has subsequently been banned by our state's Department of Environmental Protection. Today, in the State of Maine, an applicator, either commercial or private, has few options for legal and proper disposal of pesticide containers. Due to the fears of a chemophobic society, an increasing number of municipal landfills and even metal recycling facilities are becoming skittish about the acceptance of any waste associated with pesticides. In order to deal with the increasing squeeze between environmental regulations and proper use and disposal of containers, the Maine Board of Pesticides Control asked for and received an authorizing 1983 statute requiring that: 1) all containers under the scope of the act must have identifying stickers affixed by April 1, 1985; 2) a deposit sufficient to encourage the return of the container must be collected by dealers at the time of sale; and 3) containers must be triple rinsed or equivalent. As a result of a study authorized by the 1982 legislature, the Board had already determined that limited and restricted use containers were only a small fraction of the total pesticide container picture, but that the mechanisms put into place for their safe return, disposal and public oversight would be useful for the handling of all pesticide containers.

The act and the regulations which implement it are designed to: 1) provide a tracking system for said containers; 2) reduce the potential for surface and groundwater contamination; 3) provide for improved solid waste management; 4) encourage material recycling and promote refillable containers; 5) increase confidence of the municipalities and the general public that triple rinsed containers are safe; 6) prevent unauthorized use and handling of empty containers; and 7) encourage the use of the least toxic pesticide that is practicable for a given application.

On November 19, 1984 the Board adopted its regulations to implement the 1983 statute, and they cover three types of situations: 1) when pesticides are purchased within the state; 2) when pesticides are purchased outside of the state; and 3) pesticides already on hand at the time of the April 1, 1985 implementation date.

In-State Purchases. At the time of sale or delivery from an in-state dealer to an in-state applicator, the dealer shall collect the deposit in cash or posted credits on each pesticide container. For less than 30 gallons capacity, the deposit is $5.00 per container. For non-refillable containers 30 gallons capacity and over, the deposit is $10.00 per container. On refillable containers, at their option, dealers may collect greater than those required for non-refillable containers. The dealer, prior to or at the time of delivery of the pesticide to the purchaser or his agent, must also affix a sticker obtained from the Board of Pesticides Control. This sticker is an alphanumeric, designed to identify both the purchaser and the seller. Dealers are required to affix the stickers prominently and securely to containers in a manner that will not obscure or interfere with any trademark or label instruction. Dealers are allowed to place stickers on the exterior of unopened cases prior to delivery and in such event, the purchaser or his agent shall either affix the stickers to the containers immediately upon opening the case or the container shall at all times be kept with the case on which the stickers remained affixed and shall be returned to the dealer or his agent as a unit for return of deposit and disposal. Dealers also must provide an affidavit form to the purchaser or their agents at the time of delivery of the pesticide. The affidavit must contain the following provisions: the name and address of the purchaser, the registered name of the pesticide and the number and size of each container, the serial number of each sticker affixed to a container, the amount of the deposit paid or posted credit, the place where containers may be returned for refund and a certification, signed by the purchaser stating "this is to certify under oath that the containers with the sticker numbers listed herein have been properly rinsed according to the regulations adopted by the Board of Pesticides Control", and finally, the place and date of return as confirmed by the dealer or the operator of the collection, recycling or disposal facility. Once the applicator uses the pesticide, he or she must follow a triple rinse or equivalent procedure that is specified in the Board of Pesticides' regulations. Key elements of the triple rinse procedure involve complete emptying and draining for at least 30 seconds after steady flow of pesticide formulation has ceased and after individual drops are evident. A solvent usually specified by the manufacturer and capable of removing the pesticide residue shall be added to the drained container in an amount equal to 10% of its capacity. The container then shall be shaken, agitated or rolled vigorously in such fashion as to dislodge residues from the top, bottom and sides. The liquid residues or rinsate shall be added as a make-up to the spray tank and the container shall be allowed to drain for at least 30 seconds after a steady flow has ceased and after individual drops are evident. This same procedure must be performed two more times, each time allowing the container to drain for at least 30 seconds. In cases where undiluted formulations are used and rinsate cannot be added to the spray tank, the residue must be disposed of in accordance with label instructions. Any equivalent methods for removal of pesticide residues must be authorized by the Board. Once containers bearing the Board's stickers have been properly rinsed according to the Board's regulations, they may be returned to either: 1) an authorized collection, disposal or recycling facility specified by the dealer on the affidavit form - provided that the arrangements for the use of such facility have been made by the dealer; or 2) the place of business of the dealer who sold the pesticide. Upon the return of the containers and receipt of the affidavit, cash deposits will be refunded by the dealer in cash and deposits that were posted in credit will be credited to reduce such accounts.

Out-of-State Purchases. In this situation, the Board has, of course, no control over out-of-state dealers unless those dealers bring a person into the state and essentially function as an in-state dealer. In such case they fall under the previously mentioned regulations. Otherwise an out-of-state dealer has no requirements. However, an in-state applicator who purchases from out-of-state must purchase a sticker from the Board of Pesticides Control and pay a deposit on the container to the Board of Pesticides Control at the same rate as the in-state dealer/purchaser arrangement. It is the responsibility of the applicator to affix the stickers and the Board furnishes the affidavit to persons seeking stickers for containers, but the Board is not responsible for designating the final disposal site. Once a pesticide is completely used and the container is triple rinsed in the fashion outlined previously, the container bearing the Board's sticker must be returned to a Maine Department of Environmental Protection approved solid waste or recycling or disposal facility. The applicator's affidavit is then returned to the Board of Pesticides Control for a refund of the appropriate deposit.

A third and final situation covers containers on hand as of April 1, 1985. According to the statute, it is unlawful for any person to possess a restricted or limited use pesticide container without a sticker issued by the Board and affixed to the container after that date. Persons holding such containers must apply for a sticker from the Maine Board of Pesticides Control. Stickers issued by the Board under this subchapter will be supplied without a fee.

Currently, the Board is in the implementation phase of this new and somewhat novel program. Implementation covers education and development of safety procedures for applicators, dealers and solid waste and recycling facility operators. The Board's own staff must also be trained for compliance monitoring, safety procedures and for training other groups. In addition to education materials, the Board has developed, through a contractor, instrumentation and test kits for determining if containers have been triple rinsed or not. Such testing involves the use of colorimetric photometers that have previously been used in drug detection systems. Commercial marketing of these systems appears to be likely and may well represent the most interesting off-shoot of our regulatory activity.

A lot of thought, a lot of effort and a lot of consideration has gone into Maine's returnable container program. Undoubtedly, a lot of thinking, doing and bending still remains to be done, but we are becoming increasingly convinced that we're on the right track. We are already satisfied that what we're doing is worthwhile, and we're also certain that no matter what our final program may look like, we can never go back to the disposal practices of even two years ago. Pesticide container disposal is a present day problem, and as such, demands the best solutions that we can create.

SUMMARY PANEL

Roy Detweiler, Workshop Chairman
E.I. du Pont de Nemours & Co.

James N. Seiber, Panel Chairman
University of California, Davis

Jim Parochetti, USDA Extension Service
Ray Krueger, EPA Office of Pesticide Programs
Philip C. Kearney, Pesticide Degradation Laboratory
Orlo R. Ehart, State of Wisconsin
William Keane, Attorney

Roy Detweiler:

We've heard from applicators, regulators, scientists, and consultants about the needs of pesticide users. I'm sure many of us are overwhelmed and wonder where we're going to go from here. How can we use the technology that we've heard about? How can these ideas be implemented? What actions can we take? What are our future research needs? These are some of the objectives that were developed while planning this conference. There are still a lot of questions to be answered and we're really a long way from giving you something that you could put into effect and use tomorrow.

During this workshop, we've had a number of experts listening to the problems of the user community, as well as some of the proposed solutions. We're going to listen to how they would summarize the meeting. I'd like to introduce to you some of the panelists whom you have not heard from.

Jim Parochetti represents USDA Extension Service, he is Program Leader, Pesticide Application and Weed Science. We've got Ray Krueger from EPA Office of Pesticide Programs, who spoke to us earlier; Philip C. Kearney, Chief, Pesticide Degradation Laboratory, who spoke to us; Orlo R. Ehart, Chief of Pesticide Control, State of Wisconsin, and William Keane, attorney for aerial applicators in Arizona who has also spoken to us. The one man we haven't heard from yet is James N. Seiber, Professor, Department of Environmental Toxicology at the University of California, Davis. Dr. Seiber was educated as a chemist, has a Ph.D. from Utah State, was formerly involved in research at Dow Chemical, and also holds a position as Vice Chairman of Pesticide Chemistry for the American Chemical Society. Let me introduce James Seiber.

James Seiber:

Thank you. I want to express my congratulations and appreciation to the organizing committee and sponsors for undertaking a timely and useful workshop. The brochure stated that the objective of the workshop was to serve as a national forum to assess the needs of users, the available technology (and I assume technology gaps), technology transfer, how to get the technology to the users, regulatory issues at all levels, and recommendations and future actions. That's the part we're down to now, the recommendations and future actions.

We have six panelists, including myself, each of whom is going to give you their recommendations in their own areas of expertise. After that we would like you to be thinking ahead. We'd like to solicit your recommendations and comments on this conference, and where we go from here, as soon as the panelists present their summaries. Before we hear the individual panelists, I have a few comments.

My first encounter with pesticide waste disposal came five years ago at a wastewater ditch in the Sacramento Valley which had then been used for several years for disposal of application equipment rinsate. Poison signs had been freshly erected around the site, while representatives of at least four state and local agencies along with a TV station crew milled about. It occurred to me that there must be better ways (a) for the commercial applicator to handle wastewater disposal and (b) for public agencies to provide needed inputs to facilitate clean-up of sub-optimum or dangerous sites. I learned subsequently, during a 1981 summer Fellowship program at EPA's Office of Research and Development, that indeed much attention had been given to these problems by researchers around the U.S. and solutions had been proposed to alleviate the wastewater disposal problem. However, this rather large research effort was generally not known to pesticide users, partly because much of the prior work was in reports or report drafts not generally available to the agricultural community. I concluded that many of the elements for solving this problem existed, and that substantial progress could be expected in a relatively short time frame with a fairly modest effort.

My feelings have been reinforced during this conference, but I must admit to some disappointment that more progress has not taken place during the last 3-1/2 years. Among the things which I perceive have not changed since 1981:

1. We are still confusing issues. We need to separate the problem of cleanup of old, sub-optimum sites from the problem of implementing new disposal systems to handle future needs. We must also clearly differentiate container disposal from wastewater disposal. And we must distinguish between containment, detoxification, and destruction of wastes as strategies for disposal.
2. We are still hoping for that one magic answer that will handle everyone's problem. This is clearly unrealistic because the nature of application practices, pesticide use, climate, and transportation distances vary so much from location to location.
3. We are still waiting for a stamp of approval before we start recommending/installing disposal facilities. It isn't going to happen that way; some of us will need to take risks, initiate treatments or install facilities, and log some time with them to prove to the regulators and public that they will work, and do so with safety to the environment.
4. We are still looking for technological breakthroughs -- totally new concepts, which can allow us to look beyond the old, less glamorous processes (evaporation beds and ponds, carbon sorption, etc.) which are working now in several locations. While we cannot rule out breakthrough solutions, we also cannot afford to wait for them.
5. We want "fast" solutions, perhaps because we perceive that people looking over our shoulders expect the problems to be solved overnight. Perhaps we can generate "breathing room" by showing an honest effort even if it requires months or even years to complete.
6. We still want cheap solutions, even though the experience to date tells us that installation of double-lined, leak-free, fail-safe facilities with monitoring wells, etc. will cost more -- probably much more -- than we thought just a few years ago.

My recommendations to improve on the rather slow pace of progress in waste disposal in its broadest context fall into three categories. First, we need to put ourselves on a timetable, such that one year from now we can reconvene having logged experience at the demonstration-scale with several of the leading technologies for safe cleanup and waste disposal. Second, we need to call for realism on the part of regulators in implementing existing regulations and in putting new regulations on the books. Regulation is clearly ahead of development in this field, although the gap can be closed with a well-directed effort. Third, we need capital, to fund research, the installation of demonstration-scale facilities, and the development of affordable equipment by entrepreneurs. Federal, state, and private funding will all have a role to play in this endeavor, but the agricultural chemical industry could justifiably shoulder a larger share than has been evidenced in the past. At a future conference we may be able to pat ourselves on the back and say: "That problem has been solved; let's move on to something else." Unfortunately we can't say that now.

William T. Keane:

From the applicators' standpoint, I feel that this was a very productive workshop. On behalf of all applicators, I would like to thank all attendees for taking time away from their daily duties to assist us in solving our pesticide problems. This workshop was productive because it provided a good survey of pesticide hazardous waste issues confronting the applicator. On the other hand, the workshop had one major shortcoming because nothing presented is commercially available today to enable applicators to come into compliance and to stay in compliance.

I would like to remind you of the problems confronted by applicators which were outlined on the first morning of the workshop. In discussing these problems, you should recall that applicators are being told by regulators that immediate answers must be forthcoming.

1. Dripping nozzles -- There were no speakers on the topic of new nozzle research. We are still utilizing the same nozzles and nozzle technology that have been in existence for decades. Research is required to develop nozzles which do not leak.

2. Container problems -- There were no presentations outlining new, innovative container designs directed at solving the container hazardous waste problem. Indeed, Mr. Trask identified many of the areas which require research.

3. Rinsate problems -- The applicators in attendance were impressed with the activated charcoal methods of treating hazardous wastes. We feel that these methods hold future promise. However, none of these methods is available for purchase. There were no exhibitors with activated charcoal systems that could be purchased today and immediately pressed into service.

4. Collection of rinsate -- We have learned that no federally-approved blueprints exist for the construction of rinsate collection systems. On the other hand, applicators are being informed by regulators that these chemicals can no longer be introduced into the soil. Small businessmen, such as applicators, cannot afford to independently pay for the engineering research and design of workable collection systems.

5. Soil contamination -- This is the most significant, most complex, and most expensive problem facing applicators today. We have learned as a result of this workshop that no commercially available, economically feasible methods exist for removing pesticides from the soil of applicators' homes and remote work sites. If applicators were able to clean up the soil today,

they would contaminate the soil again tomorrow due to leaking nozzles and inadequate rinsate collection equipment. Soil contamination will continue to occur in the future even though applicators utilize state-of-the-art equipment, employ good application techniques, and perform proper maintenance on their equipment. One of the soil treatment techniques presented by Dr. Arthur Craigmill may hold great potential for soil cleanup, but more research is required under a wide variety of meteorological and soil conditions.

I have substantial concern that EPA regional enforcement personnel are not in attendance in greater numbers. Also, the state regulators who are responsible for enforcing RCRA (Resource Conservation and Recovery Act) are absent from this workshop. On the first morning of this workshop, I informed you of the inconsistency of enforcement of RCRA throughout the United States. Attendance at this workshop by enforcement personnel could have been the first step toward uniformity of enforcement.

In conclusion, the mood of the applicators in attendance at this workshop is one of frustration. They are faced with immediate problems, but there are no immediately available solutions. They are compelled to come into compliance, yet the scientific tools which would make compliance feasible do not exist. The applicators in attendance had high expectations for this workshop to provide immediate solutions, and those expectations have not been met. We would like to encourage the researchers to keep in mind that their target consumer is an applicator with no formal scientific training, who many times employs workers who do not speak the English language and who cannot read and write, and who works under extremely adverse environmental conditions. In short, applicators require scientific advancements which are user friendly.

Dr. Seiber:

Thank you very much Bill. The viewpoint of the applicators is extremely important. I think those comments needed to be heard. Now I'd like to call on Bob Ehart for his summary remarks. I'd like to remind you that we'd like your recommendations too, so please jot them down, and we'll read them after the panelists make their recommendations. Bob.

Orlo R. Ehart:

A significant amount of time has been devoted at this conference to what state and federal agencies have done to regulate disposal of pesticide related wastes. One aspect, however, may not have been made perfectly clear. Regulators, in general, carry out functions required of them by legislation. Although it is true that the creative genius of regulators sometimes far exceeds the intended authority provided them, it is most often the case that policies are mandated, implemented and carried out consistently with the will of the people, with adequate checks and balances on the system. Therefore, in reviewing actions which state regulatory personnel can involve themselves, it must be understood that actions will be elevated or tempered according to the state or federal authority bestowed upon the agencies and the amount of funding provided to actually carry out activities.

Although this conference has dwelt upon the regulation of pesticide waste disposal, it is short sighted not to recognize that the purpose of these regulations is not, or at least should not be, to regulate pesticide waste per se but to protect the environment. Unfortunately some of the regulations discussed appear to regulate pesticide waste but do not necessarily protect the environment.

The FIFRA (Federal Insecticides, Fungicide and Rodenticide Act) policies authorize the introduction of pesticides into the environment. The SWDA (Solid Waste Disposal Act) policies mandate a "clean" environment free from hazardous chemicals introduced by humans. Therefore, if applicators use a pesticide, they are "blessed" with the right, and responsibility, to assure the pesticide is placed where they intended to put it. Meanwhile, in cleaning up after the "blessed uses", if they leave behind any of a "dreaded" product persons may be placed in the public square and held for public flogging. This is difficult for users to understand; their actions are condoned, although usually tacitly, when they use a pesticide and condemned when they dispose of a pesticide, even though the rate of effect on the environment may be the same under both instances. This inconsistent policy, along with the fact that, the "listing" of wastes is a dynamic process, where what is legal today may be illegal tomorrow, has created a difficult situation, at best, for even the most compliant pesticide user.

The problems for a pesticide user have not been solved as a result of this conference. The lines have just been better defined. In 1974, after passage of FIFRA, and before passage of RCRA (Resource Conservation and Recovery Act), technology had reached the point where protection of the environment was at hand; best available technology was nearly economically feasible to be used to protect the environment. In 1976, with the passage of RCRA, many experts, users and others, as so frequently is the case, took sabbaticals from developing practices to protect the environment while the rules to the new SWDA were developed. Then adances in technology to adhere to the new rule began to be developed. Now, however new SWDA amendments have been passed long before even the experts have mastered the 1976 version of the SWDA changes. Compromise rules may need to be published if the goal is to return to proper protection of the environment. Activities must be better managed rather than merely regulated out of existence. Each and every user has responsibilities that must not be taken lightly if the onslaught of over regulation is to be corrected.

A minor, but important, step in addressing pesticide users' concerns is to assure that every EPA FIFRA, SWDA, and water program office -- headquarters and regional -- does receive a copy of the proceedings of this conference. In addition every SLA (State Lead Agency) for FIFRA, SWDA, and water programs must receive a copy of the proceedings. This will aid in the identification and recognition of problems and the realization of the state-of-the-art of technology to deal with the problems.

Contacts must be established between all levels of personnel responsible for the administration of SWDA and FIFRA within EPA and at the states' level. Communication on problem recognition, assessment and management must begin in earnest. Responsible parties can ill afford to continue to point the finger at another person and suggest that the problem is really the other person's concern.

Joint agency programs such as those developed between the agencies in Louisiana and Vermont are indications of the usefulness of establishing these ties. With these joint efforts a "filter point" for referrals on disposal concerns can be established in each state. Perhaps even "1 stop shopping" systems can be established where persons, wishing to comply with all related laws and rules, can have some assurance that they have been informed of all of the interregulated governmental programs which regulate their operations.

Innovations which protect the environment must be condoned even though the innovation may be only the first step in solving a larger problem. Perhaps the experimental permits recently authorized under SWDA can start that process. Regulations must become a basis for solving problems rather than merely developing mazes in the quagmire of bureaucratic red tape. Perhaps amnesty for some of the past problems rather than strict liability will provide better protection of the environment for the future. Standards for mixing, loading, and handling sites might provide protection of the environment, at least more protection than is provided by the currently unenforceable prohibition against even so much as a drop of a regulated hazardous waste reaching the ground. Container and unwanted pesticide product collection programs, aided by the government, may eliminate some problems. If incineration is to be a major answer in the future, the NIMBY (Not in My Back Yard) and LULU (Locally Unacceptable Land Use) philosophy which pervades our society simply must be dealt with; the sites and/or transfer points must be located somewhere.

To state that whoever currently owns a site is strictly liable for all past actions, regardless of how legal the actions were when performed, is simply bad public policy. To state that someone is liable for actions which were illegal or negligent in the past, currently, or in the future is another matter. Therefore, the lines which rightfully separate societal responsibility and cost from individual responsibility, cost, and penalty must be determined. If the environment is to be truly cleaned up and protected, society is going to have to accept some of the ills which have existed in the past, especially those which were done according to the existing best available technology at the time of the activity. By accepting it, however, it does not mean that clean up may not be necessary, only that a shared recognition of the problem exists and mutual responsibility for reaction to the problem is a prudent policy.

This conference has established a network of individuals interested in the solution to pesticide waste disposal problems. For that reason the ability to communicate has been aided. This conference has increased all participants' knowledge of the problem and potential solutions. It has elevated our ability to communicate to a higher level. With that in mind there are a number of items which SLA (State Lead Agency) personnel can do in the coming months.

They should act as the "filter point" for the identification of the most typical disposal and waste management questions, concerns and issues facing the pesticide users. It must be recognized, however, that some questions will not have answers; that must be clearly identified.

Uniform standards for pesticide waste treatment or disposal for all pesticide products should be developed. Separate standards for disposal of pesticide wastes of low concentration, similar to the concentration of labeled use rates, should be developed.

The location of all operating and pending hazardous waste sites should be identified so that persons wishing to comply know where they must go for disposal. If hazardous waste sites do not exist, they should be developed in each state so that problems can be dealt with on a localized societal basis.

Collection of wastes before they become problems should become a societal desire.

Materials should be developed which identify which pesticides are definitely hazardous waste and under which conditions. Specifically, it should clearly state on the label of every pesticide container whether the product is, for disposal purposes, an "acute hazardous", toxic, or some other type of waste.

Protocols should be developed for clean up of spills, fires, and abandoned sites.

Treatment systems should be categorized which differentiate between major facilities, regional facilities and on-site treatment.

The development of acceptable solutions to the problems and funding of practical disposal research should be reprioritized to be consistent with the priority of enforcing the prohibitions against any disposal practice affecting the environment.

The adequacy and availability of high quality education should be increased.

SLA personnel can do or be involved in many of these suggestions. It is obvious, that the same is true for many other persons as well. Two elements, however, must be recognized.

1) If the affected industries do not take their destiny into their own hands and work outwardly, openly and diligently toward finding solutions to the problems, SLAs will not prioritize these issues.

2) This is clearly a vote in favor of regulation. And regulations do not come without cost -- sometimes high cost. In those instances where compliance is needed, it is imperative that strict enforcement occur. If a balance between societal and individual desires, needs, and responsibilities is to be achieved it is going to cost everyone. Support, encouragement, direction, tenacity, and perhaps just a

measure of patience, both individually and societally, is needed in order to succeed in protecting the environment.

Dr. Seiber:

Thank you very much Bob. Our next panelist is Ray Krueger from the Environmental Protection Agency.

Ray Krueger:

One of the biggest problems we have in the pesticide area is the fact that these RCRA regulations and laws are here to stay. Congress put those things on the books for specific reasons, and they're there. Learn what they are, learn what they mean. Otherwise, you can't comply with them. A lot of the pesticides are not regulated. It's incumbent upon EPA to supply that information.

We'd like to mention the mixture rule. There are changes being made to it that will offer some opportunity for de-listing some of the rinses, and wastes; some of the low level stuff. Clearly, one of the methods of choice for disposal is on-site treatment. In general, that's true of the hazardous waste business across the board. No one thinks it's a good idea to transport this stuff.

On-site facilities are up for encouragement; carbon units, soil mounds, evaporation ponds, have all been proven useful. My feeling is that they need to be engineered to meet the RCRA standards. They've got to be permitted to be used. One of the things we'd like to work toward is to develop engineering specs for these kinds of units, to enable class permitting to be done. If you can build a system that meets the specific recommendations, the permit would be a rubber stamp operation.

The RCRA people have an initiative going for storage facilities. It lessens the work load of EPA and state regulators, releasing them to do other things.

Experimental units: there is going to be relief in this area. From the new amendments, there are provisions in there for permitting experimental facilities. We need to coordinate very closely with the small quantity generator information programs to be put into effect later this year.

There is a need for better disposal statements on labels. To do this we've got to publish guidelines for the manufacturers to be able to submit necessary data to support the disposal system of their choice. Such things as instructions on how to hydrolize any residual material, or possibly a small bag of enzymes taped to the outside of the container with instructions to empty this bag into the container when you're through, add a little water, let it sit for an hour, and you have a non-hazardous waste. These would be exempt wastes, not regulated by RCRA, and you wouldn't have that problem.

This workshop has been a learning experience for me. I've learned that there are more problems than solutions. I feel it has been profitable. I regret that we have been unable to give the magic overall solution to your problems in one motion. But as Jim pointed out, that does not exist. Thank you.

[Applause]

Dr. Seiber:

Thank you Ray. There has been a lot of discussion and recommendations about disseminating information to get information in the hands of those who need it. We're putting Jim Parochetti from USDA on for his comments and recommendations. Jim.

James V. Parochetti:

Extension Service is proud to have been a sponsor of this workshop. The Extension Service and its affiliated State Cooperative Extension Service have, since the mid 1960's, been actively involved in pesticide education for the pesticide user, both farmer and commercial applicator. A majority of the land-grant universities were represented at the conference which is indicative of our commitment to research and extension in matters relating to pesticides and, in particular, pesticide wastes disposal. We, from the land-grant universities, at this meeting have learned a great deal. One of which is there is a considerable amount yet to be implemented at the user level with regard to the proper disposal of pesticide wastes. The rules in technology are continually changing which makes a task of Extension education difficult at best.

The teachable moment, however, is at hand evidenced by the several hundred people in attendance.

Recommendations

1. A recommendation which is made by the Extension Service for the Extension Services is that we will continue our commitment to provide the best educational programs tailored by each State Extension Service on pesticide waste disposal. Our focus is education which is an important component of the solution to the problem.

   I would like to stress that this is a continued commitment of education. All states have a pesticide education program (general) and a more specific educational program with regard to the training to enable pesticide applicators to become certified, i.e., the pesticide applicator training program. This program has provided information in the past on pesticide waste disposal but a greater emphasis will and must be made in response to the users' needs and demands at the state level.

2. The Extension Service recommends that those at the Federal level specifically, and in each state where the Extension Service is conducting educational programs that have a responsiblity for RCRA and FIFRA, provide the technical interpretation for all of us. The Extension Service and the State Cooperative Extension Services then, in turn, can and shall distribute these interpretations to the States. A recommendation was made in the first day's sessions of this workshop that Extension Service be the interpreter of the regulations. This is not acceptable to the Extension Service. The Extension Service walks a tight rope between regulations and education. Our function is education. When one walks a tight rope one runs the risk of falling off that rope. Therefore, we leave the interpretation and the development of fact sheets to those that are responsible for enforcemnet and interpretation of RCRA and FIFRA. The Extension Service will not jeopardize its role as an educator by interpreting rule making.

In summary, I would like to make the analogy that this conference is very much like a child's puzzle. There are large pieces that have been put together. We see the general outline of the picture but there are one or two pieces missing. We are going to find those pieces and put them together. We must because the pressures of enforcement are upon many users.

Dr. Seiber:

Thanks Jim. Now I'd like to turn to Dr. Phil Kearney, USDA/ARS for a summary of research needs and research recommendations in this area. Phil.

Dr. Phil Kearney:

Thank you Jim. This is a shared effort. I'll give you some of my impressions, and I'd like Jim to follow up. We were given a format in this discussion panel, to talk about problems, solutions, needs, and workshop accomplishments. Some of the problems here are like the joke about the real estate salesman. A fellow said to him: "What's the most important thing when selling a piece of property?" The real estate salesman said: "There are three things: location, location, location." The problem with waste disposal is cost, cost, cost. Just that.

We have looked at a lot of processes over the last few days. I hope you looked at some of the cost figures involved. Some of them are mind boggling. We have to resolve this cost issue. I have some ideas.

Another problem we have is regulatory constraints that limit our flexibility. It could stifle innovation. Before I came here I was willing to take a number of chances looking at new processes. I wonder whether we, as a research organization might have to come under these same regulations.

Another problem we have is unique to the pesticide applicator field. We're not really dealing with concentrated solutions. It's been a hard message to get across. Our problem is the rinsing from the can, the tractor, spray tank, and the airplane. At the current costs of pesticides, we better not dispose of large amounts of concentrated materials; it's too expensive. The problem has been high volume, low concentration, low value wastes. We have some ideas, but we don't have a process that we could give you a solution which will satisfy all of our needs.

A final problem that this meeting may have generated is a level of expectation. I sensed that. Someone said to me today, to understand our problem I've been to a number of these conferences over the years. We've solved the problem many times. We haven't listened to what these people can afford, what their problems are, or the magnitude of the problem. I thought the ground and aerial applicators shared some useful information with us. Not all of their information, for obvious reasons has been shared. [Laughter]. I'm like the Catholic priest, I won't tell you their confessions. They have problems.

Some of my impressions are that land disposal may be regulated out as an option. That's disappointing. It's a widely used, economically used method of waste disposal. I am so confused about the regulations that I'm concerned about using it as a method. Some of the chemical options are good, but very expensive. If they are to be successful, we've got to think about bringing the cost down. Absorption looks good. But I am concerned about running into a problem of a secondary residue. I worked for 10 years trying to dispose of Agent Orange. We looked at literally hundreds of proposals for destroying it. One of the most innovative was to package these materials in a box with a Woodies label on it, park it in your car, park the car on 9th St., and leave the doors unlocked. [Laughter].

Some of the biological processes hold promise. The high-tech, genetic engineering will play a role. We have a small unit in genetic engineering which is growing, which is going to be very expensive, but which is very specific. Some have a broad specificity, and some are narrow.

Let's talk about needs. One of them is a time of development. We need a period of grace to develop the technology and to come into compliance. We in technology can't meet the regulations, but I think the agency has time to enforce them. Whatever the process is, it should be shared with many users. We have to share the cost over a large population. It has to be durable, and last for a number of years, have a low maintenance cost, and be mobile. If its mobile, it'll take it out of the hands of the user. I am concerned that the user will need to become a chemist. I also don't want to build a lot of monuments. We need the ability to replace and update materials and processes as innovations become available. That's why I like mobility.

The rate of flow must be good, we must be able to accomodate large volumes. The purchaser may not make a profit, the producer might, but the person that provides the service may not. It may have to be a formulator, or a co-op, which is a possibility. We're reluctant to gamble here, until we know what the ground rules are. We can't take a big plunge with big dollars in programs, or someone's money.

A fourth need is that field trials should begin this summer, to be reported back next year. The workshop accomplishments were an excellent review of current knowledge; state-of-the art. The speakers were good, but I also leave here with a sense of urgency that we do something. Thank you.

[Applause]

Dr. Seiber:

Thank you Phil and thanks to all of our panelists. We'll turn over the floor to Roy Detweiler again for a reading of the questions that I hope you'll come up with and recommendations from your perspective. We all pretty much agree on a timetable. Phil suggested that we get together in a year from now and compare notes. I think that's a good idea, and we'd like to hear your remarks. Second thing that was said was regulations are ahead of development. I think we need to take that to heart. We need to make sure that the message gets in place at the local, state, and federal levels.

Finally, Jim said that we've not given everyone everything at this conference. We know the problem a lot better. We have a better sense of urgency. Someday at a future conference, we can pat ourselves on the back and say yes, we solved the problem. We can move on but we're not there yet with pesticide disposal. We still have a long way to go. Roy, we're ready for the questions.

First, let's have a hand for the panelists.

[Applause]

We've had a couple of cards about a follow-up conference. And a very good suggestion from Francis Mayo, EPA Research Director, who suggested that I ask for a show of hands to see whether the interest is there for a future workshop. Please show your hands. Just about unanimous.

Also EPA would be willing to co-sponsor such an activity. We will certainly put that into our committee. Our committee will be meeting at 2:00 PM today to decide where to go from here.

I've got a number of questions here, and I'll divide them up so everybody can participate. Phil Kearney, can anyone name sources that are available for research?

Phil Kearney:

I don't know, there is the NAPIAP funds, and some of the state people know what I'm talking about. This is the National Agricultural Pesticide Impact Assessment Group. They have funds designated thru ARS and CRS. I don't know how many dollars are left. Those funds may be available. That money may be narrowly aimed at other problems. I'm not optimistic. I'd like to see some funds made available by the agencies. Industry has to really look hard at this thing because we're all going to suffer if we don't solve it. It is going to put burdens on the users, sales people, all levels. I'd like a special fund set up to do this and see what we can identify as a source of funds. People may have to compete for these funds. We have to do it soon.

Roy Detweiler:

This next one could be answered by any of the state or federal people. Which agency or organization will develop a central clearing house for information on pesticide waste disposal research?

Jim Seiber:

I can say who I would like it to be. At the federal level, I hope the EPA and the Office of Pesticide Programs could make that information available. At the state level, I'd like to see it be the state lead agency in each state. In California it would be the Department of Food and Agriculture.

Another element is that EPA is talking about monitoring an environmental area, establishing an electronic bulletin board that would give not a lot of information other than just the essentials -- who's doing it, and what the concept is. It would be available to anyone, electronically.

Roy Detweiler:

This is for Bob Ehart. This conference has identified the problem with regulatory pesticide waste disposal by the RCRA people. Would the state pesticide programs and EPA's OPP be willing and able to address the problem except for the obvious unused, banned, and overage products identified repeatedly as hazardous? Can this group push to get a major change out of EPA?

Last part answered first. Yes. This group can push to get changes. I think there are a number of things that can be done as to who is going to be the responsible agency. What it comes down to is the first part can be answered like the last. That movement is going to have to come from you, not from us. If I mentioned that I want to take on pesticide disposal in the state of Wisconsin, it becomes a turf battle between the Dept. of Natural Resources and the Dept. of Agriculture. The legislature doesn't look kindly whan I state things such as that. They think I'm a dynasty builder. I think it has to come from a grass roots movement. There can be changes in it. Vermont and Louisiana have joint programs, where most of the responsibility is under the state agency for pesticide.

Roy Detweiler:

Jim Parochetti, this is addressed to you. You stress the importance of education, but states don't have the funds. How can we move into education with such a lack of funding?

Jim Parochetti:

We have a responsibility to disseminate information and I'm aware that funding is available. There is no question that funding is going to be limited now, and in the future. I don't have a good answer to that. My response is that we have an obligation and to the limit that the states have resources and the federal government provides funds in support of the state program, that's the extent that each state is going to have to evaluate their educational program.

Roy Detweiler:

Does anyone else wish to add to that?

Ray Krueger:

I'd like to make a comment. I've been listening to some of the questions and answers, and it seems to me that we're letting industry off a little easy. I think industry bears a little responsibility to fund some of these things where we don't have funding. This is true in research and information dissemination areas, and as far as coming up with concrete suggestions, like what temperature it takes to break down one of their products in an incinerator. I'm not sure the EPA should be looked at to supply that information. I don't think the state universities and extension service should supply that information.

Roy Detweiler:

I agree. We have that information on our products, and we should make it available. Anybody else? OK, we have one here that Bill Keane, could probably address. This is a statement that says: "Loading sites should be ruled on an equal basis so that no one type of applicator is at an advantage or disadvantage in the market place, referring to ground, and other types. No one size operation should have an advantage." Just make a comment, please Bill.

Bill Keane:

I think the whole soil contamination issue is an extremely important issue. If we were to dig up and transport to our closest hazardous waste site all the pesticide contaminated waste sites in Arizona, we would be shipping it to West Covina, California. If we were to do that, I think our Chamber of Commerce could advertise, if you want to visit Arizona go to West Covina, California. Incidentally, now I know what to do with our containers, we could ship them to Canada. [Laughter].

In all sincerity, I have difficulty understanding when pesticides which are designed and intended and approved/registered for use on agricultural fields when everyone in the room knows that a given fixed percentage of those pesticides will find their way through the plant canopy and down into the soil. Somehow, we're saying that the pesticides that are getting onto the soil from the approved labeled use and application is acceptable, though they aren't regulated under RCRA. On the other hand, the identical pesticide in a non-target area is illegal and subject to disposal.

It's going to be a tough issue for the EPA to legally uphold and defend in court. I hope it doesn't come to that. In fact, one of the easiest solutions to this problem appears to be, why can't we dig up that soil and spread it out over the agricultural fields. An extremely thin layer or concentration rate. Sample the agricultural field before we put it on so we know what the residue levels are pre-existing and after we spread out this soil. We can analyze again with time to prove it's broken down over time.

All the registrants have been telling us for years that one of the quickest ways to break down pesticides is by ultra-violet rays from the sun. We get it for free if we spread the pesticides out on the soil over big surface areas. Its all handled for us by Mother Nature. My applicators don't understand why that isn't the proper solution.

Roy Detweiler:

Thank you Bill. I think we have the world's best expert, Phil Kearney. Maybe you could add to that.

Phil Kearney:

Well, you know I'm a high-tech guy, and I like all these enzymes and things, but you know there is much common sense in that kind of solution. One of the problems with common sense, is that it's not very common. That idea seems to have a lot of merit to me.

Roy Detweiler:

How about Ray. Can you pick that up and put it into your pesticide program?

Ray Krueger:

Well, it would be a nice idea, but unfortunately it's a disposal technique called "land spreading, or land farming," which is regulated by the RCRA rules, and any operation of that kind would have to be permitted and meet the requirements to obtain to that permit.

Roy Detweiler:

Here's another subject, it's directed to Dr. Seiber. To determine if effluents from treatment and disposal facilities are acceptable, government needs to establish concentrations of mixtures which will be considered "non-hazardous" and also facilities operated will need effective and acceptable analytical procedures to characterize their waste streams at lower cost than currently available.

Dr. Seiber:

Well, that's true and that's a research need that's worth repeating. The need for simple on-site monitoring techniques to check whether a treatment system is working. We've heard about double liners, and the need for monitoring wells, and impoundment systems. I think a lot of people would be willing to go along if they could take a sample and get an answer the same day. When they send it to a lab, spend $200.00 and wait 3 months, its just not acceptable. We need on-site, cheap monitoring techniques. I feel this is an area for research.

As far as setting the standards, that's a whole different subject. In the State of California, the Dept. of Health Services is setting levels of how clean is clean for various situations.

I'm not part of that decision making. They take toxicity and other things into consideration and are coming up with standards. We're going to have to live with the standards they come up with.

Roy Detweiler:

Anybody want to add to that answer? I have one that's directed to Ray Krueger. I know you can't answer it directly, but they wanted to ask where are the hazardous waste sites. Is there such a list? Is it available to people that want to use them?

Ray Krueger:

I don't believe there is a published list. The agency has a listing of all the facilities that are permitted to treat specific waste. If you went to the regional office, and asked where can I go with it, they could probably give you a list of facilities that could handle it. There area growing number of waste brokers, people who have no waste facility of their own but do have connections with permitted facilities that are listed in the yellow pages. They will contract with you to dispose of your wastes and work a deal with the waste disposal people. The problem is that they're all expensive. We're trying to avoid that burdensome cost on the applicator.

Roy Detweiler:

I've got a question/comment here. Of the 400-plus attendees, this meeting represents a very small percentage of those involved in pesticides use and disposal. Why wasn't this conference given wider publicity?

I guess I can say that we felt the 400 was a good response. We used all the methods that we had available at the time to publicize it. We were expecting between 100-300 people and we have 400, so we think we did pretty well. Back to the panel.

This is to Bob Ehart. You've made several points about what should be done to improve the system, to educate the users and the public, and to update the enforcement activities of the agencies. Someone needs to push this. Maybe we could help promote them to the respective state personnel.

Bob Ehart:

I was wondering how to weave in something that I wanted to leave as a message. There has recently been formed a committee of state, RCRA, FIFRA, and Water people, along with the EPA, to continue discussions on solutions, directions, where we want to go, and answers to the most typically asked questions. The full intent of that group is to focus on those issues. There are also people from the extension service, who are looking at it from the educational perspective. So there's a committee function that is purposely established to address the ground water protection and disposal elements. It's something we feel strongly about for looking at resolutions and directions. I encourage you to make your comments known directly to me or your state lead agencies. A lot of those things will begin to surface and directions will be given in that forum.

Roy Detweiler:

This is directed to Kruger/Ehart. There will need to be a change in permit requirements under RCRA for the average agricultural retail facility and aerial applicators to be willing to use treatment for disposal technology. The present TSD requirements are too tight for the average businessman. What areas are government agencies willing to review under existing regulations to allow our industry to use new practices? Ray?

Ray Krueger:

I can answer it in one word. None. The reason being that the RCRA regulators regulate hazardous waste. Pesticides are a sub-set of that unit. They are not about to make special provisions for special parts of it. Class permitting might be possible, but as I indicated before, there are engineering requirements to be met there to be able to meet the permitting standards.

Roy Detweiler:

Please outline who is or will be considered a hazardous waste generator under the various laws. This isn't clear and they are referring to the small generator exemption. Could you verify? They are referring to the 100 kilogram per month requirement.

Ray Krueger:

What that means is, if you produce and dispose of more than 100 kilograms in a month period, you are a regulated generator. That means 100 kilos of hazardous waste. Non-hazardous materials won't put you into that category.

Roy Detweiler:

Somebody here will have to deal with collecting, shredding, and burning polyethylene pesticide containers with adequate air. Why doesn't EPA design and operate such a facility? Re: incineration facility.

Ray Krueger:

EPA is not a service organization. Congress appropriates money for specific operations. They wouldn't let us do anything like that.

Roy Detweiler:

Is there an import quota on Canadian logic.

[Applause]

Speaker(?):

As an uncommon man, I'll try to use some logic on that. It seems to me that the Canadian government has decided they have some responsibility to solve the problem. I've indicated that our federal government helped cause this problem, and I think they should help solve it. With respect to the land farming issue, why can't we go to our USDA research farms, our farms with land grant colleges, have them permitted as hazardous waste sites, and let us spread our soil over those permitted waste sites, and have ultraviolet light take care of it.

One way to help solve the rinsing problems of containers, when an applicator is away from his home location, is to carry a drum of clean water on the unit. It will help with containers, and solve the exterior wash down problem, also provide a solution to rinsing before the container dries out.

Bill Keane:

Our ground rig applicator said that many times he goes as far away as 70 miles from home, for at least a week. Many times they work in areas where there aren't additional volumes of water that they have access to. So it isn't that easy a problem.

Roy Detweiler:

Some suggestions for industry. We have a sub-committee container meeting at 2:00 PM that has to do with standardizing containers, simplifying container disposal, addressing the ultimate way to dispose of containers, etc. Several people have suggested that the list of attendees be expanded to include addresses. We'll consider that. You may know that the proceedings will be published by EPA. They're paying for it. There is a suggestion here that the proceedings could be made available to others that are not attending this conference through the NTIS, which is the national technical information center. So with that I want to thank the panel, thank all of you who have come here to our first workshop. We also want to extend thanks to the Clarion Hotel, JACA, and NACA staff, the National Agricultural Aviation Association staff, our committee and our sponsors.

[Applause].

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